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Dual-Purpose Optical Sound Prints

By C. E. BEACHELL and G. G. GRAHAM

This paper describes a method of recording and printing two separate sound tracks within the normal single-track area for 16mm or 35mm release prints. A projector conversion kit for reproducing the double tracks separately or simultaneously is also discussed. This technique has possible application in reducing distribution costs on foreign versions and in the educational and television fields.

IN VIEW OF the greatly increased use of films in the fields of government, education, television and industry, it is often desirable to have available alternate sound versions of certain productions in order to serve the widest possible audience.

Typical applications of these versions are:

(a) For distribution in foreign countries.

(b) For presentation to audiences of different intellectual interests and training. For example, a drug firm may wish to present one technical version of a treatment to a medical audience and, using the same visuals, also present a lay audience version.

(c) For television presentation it may be necessary to present a film minus the music track because of trade regulations.

Because of these and other potential needs it is now common practice for many film production units to record, in addition to the original language version of the film, a separate music and effects track and a voice and effects track. The music and effects track may be used for foreign or other English language dubbing and the voice and effects track may be used for television prints where restrictions on the musical score are in effect.

The details of preparing an alternate sound version of a completed production vary somewhat in different studios, but in general they follow this pattern.

First consideration must be given to the economic factors of distribution which in turn will indicate the most desirable method of presenting the new sound treatment of the film to the public. With an eye to the budget, the producer and distributor will probably discuss these techniques:

Presented on April 25, 1952, at the Society's Convention at Chicago, Ill., by C. E. Beachell and G. G. Graham, National Film Board of Canada, John St., Ottawa, Ontario, Canada.

(a) The sound volume on the projector may be turned down and a commentary may then be supplied by the operator. This method is often used in schools with reasonable effectiveness but in the hands of an inexperienced person the results can be disastrous.

(b) Subtitles may be added to existing prints, which have completed domestic distribution, by means of an etching process. If additional prints are required, subtitles may be printed from mattes. Choice of either of these methods depends upon the volume of prints required.

(c) For prestige purposes and/or commercial distribution completely new sound tracks may be prepared which will permit the film to be presented as a standard composite print. Current developments in magnetic striping of existing and new prints suggests a further method of presenting this type of version.

Perhaps it is in order to discuss methods (b) and (c) more fully.

Etched Subtitles

In this process, subtitles giving the essential text required to explain the action of the visuals are added to the lower one-third to one-quarter of several frames of each scene by means of these steps:

(a) The print embossing plates which provide a relief image of the text type are made. One European process permits direct typing on the film and thus obviates the need of individual type plates.

(b) The print to be subtitled is coated with a bleach-resistant material such as paraffin wax.

(c) At the desired places throughout each reel the printing plate is hot-pressed on the coated film so that the type image penetrates to the emulsion surface.

(d) The film is then run through a bleach and clearing bath during which the image in the type areas is completely removed.

(e) The wax coating is removed with suitable solvent and the subtitles appear on the completed print as white letters.

Matte Printed Subtitles

In this process a text similar to that described above is applied during the release printing operations as follows:

(a) Individual title cards bearing the text for each scene are prepared and shot on the animation stand. If more than one set of mattes is required, black letters on a white background may be used to provide a printing negative.

(b) The negative titles are now printed on positive stock to provide black letters against a clear base.

(c) The subtitle printing matte is synchronized with the release printing picture negative and both of these films are run through the printer in contact with the positive raw stock. The text appears as white letters against the picture background.

This is a deliberate simplification of the preceding process which involves much more consideration of negative and positive print densities in the subtitle areas than is indicated here.

Dubbing

Most of the foreign language dubbing is presently done in Europe where considerable skills in translating and recording lip-synchronized dialogue have been developed over many years. The advantages of this arrangement are:

(a) Translations may be obtained which contain the current idioms of the area in question and which avoid offensive reference to controversial questions involving the national, political or religious beliefs of the country concerned.

(b) A relatively large number of translators and actors are available who have a detailed knowledge of the English language and who are trained to inject the proper feeling and authenticity into the characterizations.

(c) Most distributing firms have funds frozen in various foreign countries and

this fact, coupled with restrictions on the import of prints from hard-currency areas, makes this method of operation desirable from an economic standpoint.

Recent developments of magnetic striping, such as those described at this Society's conventions and in the *Journal*, have opened up further possibilities for the application of alternate sound tracks to existing prints. The high quality of reproduction obtained with this system along with the simplicity of operation should permit its use in the foreign or alternate English version field in a most practical manner.

Obviously the application of a foreign or alternate English language track to a commentary-type film is a reasonably simple operation. It becomes quite complicated, however, when the sound must be supplied as dialogue to match the lip synchronism of the visuals. Special techniques for analyzing the voice portions of the original track and selecting words in the new version which match the phrasing and inflections of the original have been developed by De Lane Lee and others in Europe. Individual scene loops are recorded on magnetic stock in an erase-record cycle until a desirable take is secured. The individual sequences are later mixed with the music and effects track (which has been recorded previously) to provide the completed track. Usually new titles are prepared for release printing versions of this type and with these cut into the printing dupe and synchronized with the sound track the film is ready for release printing. Although this latter method requires the making of a new sound track, it is presently considered to be the most effective way of presenting a supplementary version of a film. The methods and techniques to be discussed in this paper deal with the application and utilization of such alternate sound tracks.

The National Film Board of Canada is faced with the continuing problem of producing films in both the French and English languages for its domestic distribution. In addition to this, the prospect of increased coverage in Europe to assist the Canadian government's immigration program as well as greater activity in the fields of education and television led to study of methods to provide greater flexibility in the utilization of 16mm and 35mm prints.

The use of subtitles was considered and abandoned for these reasons:

(a) It is extremely difficult to present sufficient text within the space allotted in documentary films where the commentary is not necessarily linked to the visuals in an obvious manner as is the case in a story-line type of film.

(b) The attention of the spectator must be divided between the picture image and text, and consequently the ability to understand the film is reduced.

(c) In many areas of the world it is desirable to show the films to illiterate audiences which, of course, reduces the effectiveness of this method.

Magnetic striping provides an acceptable quality sound track and is ideal in certain circumstances. Its principal disadvantages at this time appear to be:

(a) The cost of new projectors or converting existing projectors is quite high. This is particularly significant in areas where several hundred projectors are in use.

(b) The cost of striping a print and transferring the new sound track adds considerably to the sale price of the print.

(c) The fact that the sound track can be erased and replaced with an entirely different track without reference to the original producer could have serious consequences. By design or accident, interpretation of the visuals could be used indiscriminately to express opinions which would cause embarrassment to the organization or country responsible for production and distribution of the film.

As a result of these conclusions and to meet the needs of other agencies of

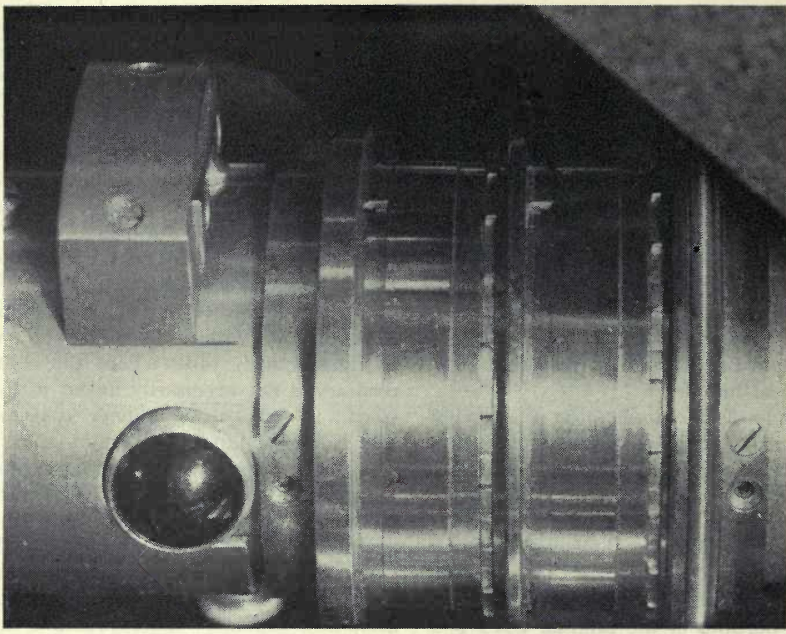

Fig. 1. Close-up of Debrie Sound Adaptor, showing sound aperture masks in position.

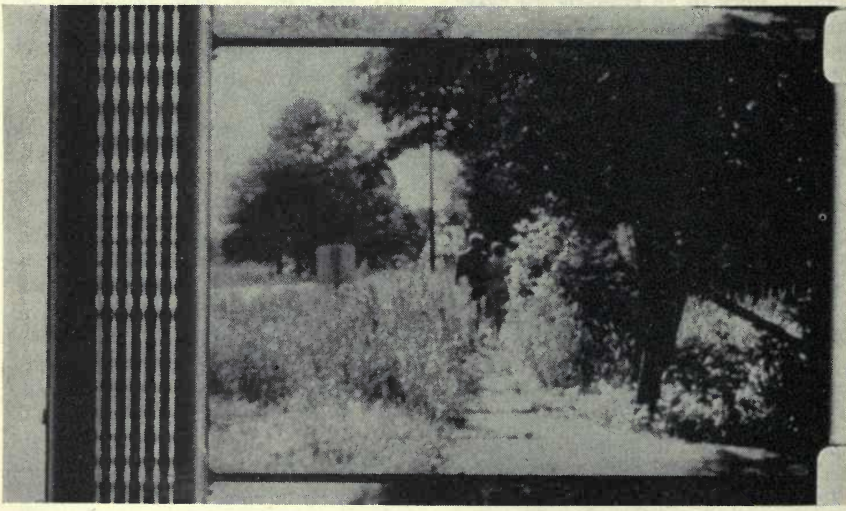

Fig. 2. Normal track provided by Maurer Sound Recorder.

government concerned with film distribution the following objectives were established:

(a) The overall quality of the sound should not be impaired.

(b) The technique devised must be applicable to existing films as well as those to be produced in the future.

(c) In view of the capital investment in projectors, any method of changing the character of the sound track must be accomplished through adaptation of available equipment. It was, of course, mandatory that any conversion unit applied to the projector must not, in any way, prohibit its use for projection of standard films.

(d) The technique developed should insure an appreciable saving in print costs to the distributor and consumer.

(e) The sound track supplied should be that prepared by the producer of the film and should remain a permanent part of the print itself.

In view of the success achieved in reproduction of the 50-mil optical track portion of the striped magnetic sound systems, it was decided to concentrate on producing a double optical sound image each portion of which would be 50 mils in width. Either of these tracks could then be reproduced at will by simply inserting a suitable mask in the sound scanning beam of a 16mm projector.

In preparing these dual-purpose sound prints it was found that two methods could be used. With the use of half-width masks alternately on opposite sides of the sound aperture and a double printing operation, the prints may be made from existing sound negatives by the processing laboratory. To avoid the double-printing operation, a similar masking technique may be used on an optical recorder. In this case two separate recordings are made in the standard single-track area on an interlock system by exposing one side, then reversing the mask, rewinding the stock and exposing the second half.

Adaptation of Printers

For the preliminary experimental work a double sound head Debrie Matipo printer was used. The alternate halves of each sound aperture were masked with brass shim stock suitably blackened to reduce reflection (Fig. 1). The Matipo printer is particularly suitable for this work since the sound gate is slightly undercut from the film path. Consequently a mask may be inserted in such a manner that it clears the moving film by about 0.010 in.

To adjust the mask a standard negative is placed in its normal position on the aperture. Over this a piece of positive raw stock is placed so that the image of the track and the mask impinges on it when illuminated by the printer lamp. With the use of a toolmaker's microscope, the mask is moved to split the track at the 50-mil position. Fine centering of the mask image on the positive stock is accomplished by adjustment of the printer-lamp position. Figure 2 shows a section of multiple bilateral track from a Maurer recorder. The track is split in printing half-way between sections 3 and 4.

Two samples of tracks printed and recorded in this manner are shown in Figs. 3 and 4. Figure 3 shows the result of mask overlap of approximately 0.010 in. which causes a loss of two tracks. Figure 4 illustrates a finer adjustment of the masks to eliminate the unexposed center strip completely.

When it was established that the unexposed center area could be eliminated, an alternate use of this technique suggested itself. Instead of putting entirely different sound tracks on each 50-mil portion, it might now be possible to print or record different portions of the same track on each half-track portion. To check this reasoning a special mix of a sound track was prepared. The tracks to be mixed consisted of two music, and four voice and effects reels. From the dubbers the sound was fed

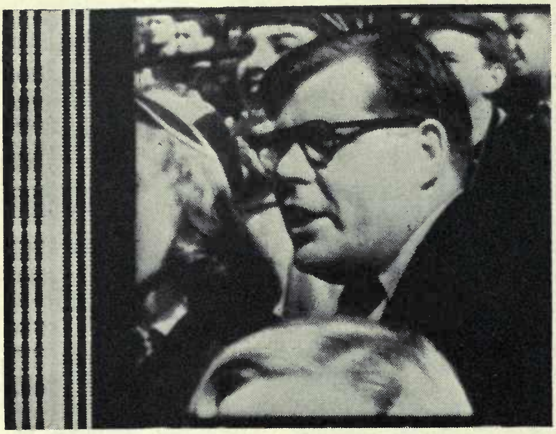

Fig. 3. First track split, showing effect of mask overlap.

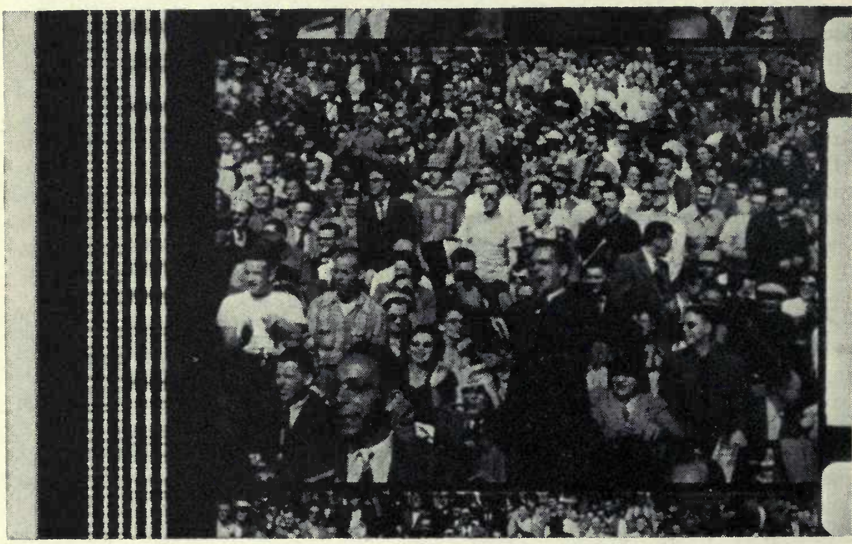

Fig. 4. Second track split, with masks adjusted to eliminate overlap.

as shown in Fig. 5. The mixer heard the combined effect of all tracks over his monitor speakers, but at the recording stage the signals were bridged so that the music was recorded on an interlocked magnetic recorder while the voice and effects were picked up on a masked optical system. The magnetic track was transferred to the opposite half of the optical negative and the combined tracks were printed onto the positive stock. When played on a standard projector the full track is reproduced, while on an adapted projector the print may be played as full sound, voice and effects, or music only. This type of print appears to offer certain advantages:

(a) On full-track reproduction, since

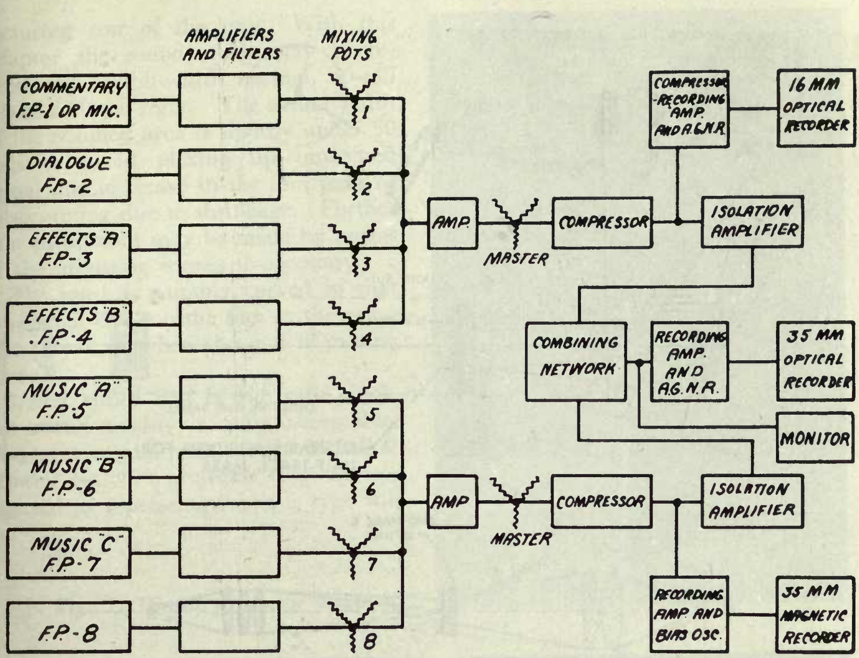

Fig. 5. Diagram of divided track re-recording system.

the high- and low-frequency components are physically separated, intermodulation distortion effect in the recording and printing stages is greatly reduced.

(b) The music portion only of the track may be reproduced when, for example, the print is used for educational purposes and the teacher wishes to supply his or her own commentary. Alternatively, many teachers feel that music detracts from the effectiveness of an education subject and in such cases the voice and effects portion alone may be used.

(c) A third possible application lies in the television field. Split-track prints may be distributed generally for reproduction on standard projectors. However, the same print may be rented or sold to television stations which in turn may reproduce only the voice and effects portion. This eliminates the need for special prints of sound negatives where trade regulations prohibit the reproduction of film music on television networks.

Mechanical Adaptation of Recorders

Figure 6 shows plan views of the RCA and Western Electric optical paths. Suitable half-track masks could be installed at the points shown. In the Maurer recorder the mask is introduced at the ultraviolet filter holder position so that its image is produced sharply on the film in the desired position. During the early experiments masks were used at the film plane for reasons of convenience. However, the points noted in Fig. 6 would permit a more precise arrangement for continuous use.

Split-track recording may be used for two purposes:

(a) To divide the contents of a single track into two portions: i.e., music, and voice and effects; or music and effects, and voice.

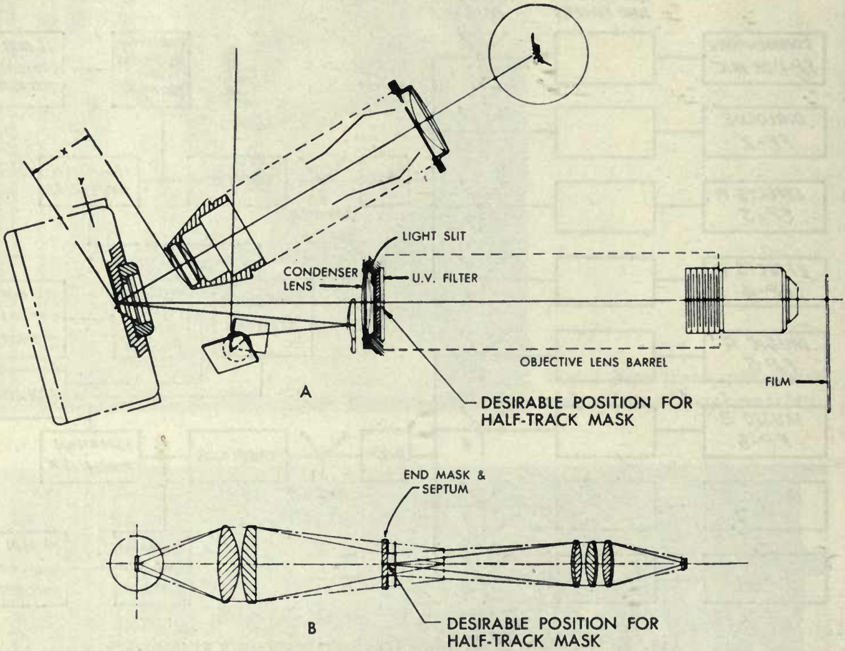

Fig. 6. (A) RCA Optical System, plan view; (B) Westrex Optical System, plan view.

(b) To place within the single-track area of a standard 35mm or 16mm negative two separate sound versions: i.e., English and French tracks, two English tracks, etc.

Where separate language versions are required, the originals are recorded separately in the regular manner on 35mm magnetic stock. These tracks may then be transferred to the masked recorder as described above.

The particular advantages of double-track sound negatives are:

(a) The laboratory printing step is reduced to a standard single operation and consequently two print versions may be produced for the price of one.

(b) Any overlap of the masks on the sound negative record is reproduced as a continuous black unmodulated line on the print. This is preferable to the white line left by overlapping of the masks on the release printer since this would raise the noise level when reproduced on full-width scanning.

(c) On a recorder greater accuracy of center-line placement can be assured and the danger of clipping is reduced. In addition, negative recording stock is usually in good physical condition so that no compensation for shrinkage need be applied.

Projector Conversion

The prototype model shown here (Fig. 7) is a very simple adaptor which may be fitted to most 16mm projectors. The pivoted mask is U-shaped, with adjusting screws for proper horizontal positioning of the projector sound scanning beam. Since the vertical dimension of the scanning beam is defined by the optical system of the projector, no provision need be made for this on the adaptor. This fortunate circumstance greatly reduces the manu-

facturing cost of the unit. With this adaptor the sound track may be reproduced as full-width normal, 50-mil left and 50-mil right. The actual width of the scanned area is slightly under 50 mils to avoid picking up unwanted signal due to weave in the film path or miscentering due to shrinkage. Further fine adjustment may be made by means of the adjusting screws if necessary.

The mask is suitably curved so that it will not cut into the film in the event of a break or when the end is passing through.

Using either half of the split track, the sound quality is quite acceptable. For experimental purposes an old Bell & Howell No. 179 projector (Fig. 8) was selected as representative of a type still

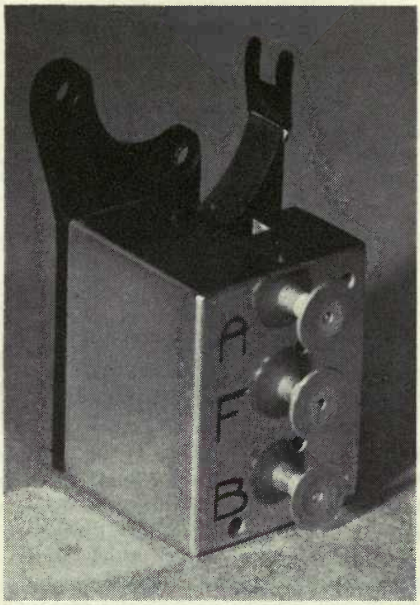

Fig. 7. 16-mm projector adaptor.

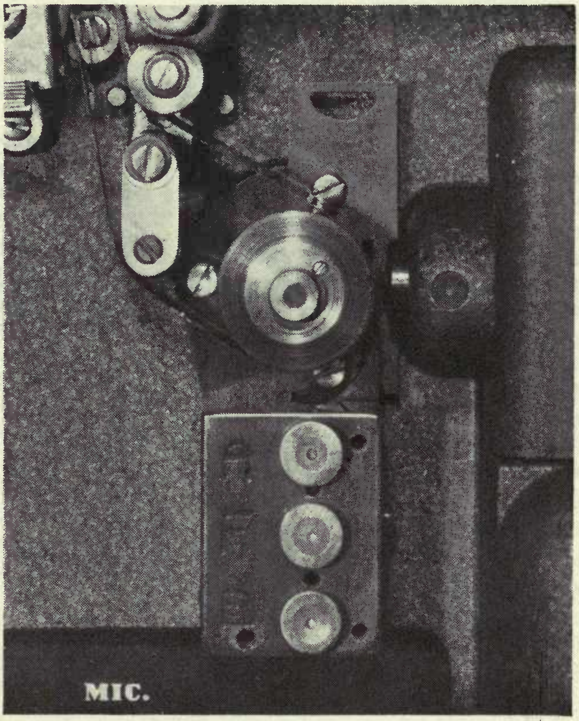

Fig. 8. Adaptor in position on Bell & Howell, Model 179.

used extensively in Canada. With the amplifier in good working condition and the sound scanning beam balanced to $\pm 1\frac{1}{2}$ db across its full width, the sound level of the half-track is down approximately 5 to 6 db. The frequency response characteristic remains unchanged. Signal-to-noise ratio of the projector is not affected since the scanning beam is mechanically reduced by one-half. There is an increase of amplifier noise since the gain must be increased to compensate for the volume loss on the half-track. However, this is not serious for all normal requirements.

While this system is particularly adaptable to variable density and multiple bilateral area tracks it is also applicable to other types of area tracks with the exception of unilateral records.

In conclusion this 50-mil optical track system appears to offer the following advantages which are applicable to either 35mm or 16mm black-and-white or color film prints:

(a) Double- and possibly triple-version tracks may be produced on a single print at very low cost, thus introducing economy for film users in various fields.

(b) Using the split tracks for independent recording of the low- and high-frequency components of a single sound track will reduce intermodulation distortion. By means of selective playback, greater utilization of the same print may be made.

(c) The cost of adapting a projector for this purpose will probably be less than fifteen dollars per machine and the adaptor will not, in any way, limit the projector for use with regular films.

Discussion

John G. Frayne: I would like to offer a suggestion if I may to Mr. Graham. It's possible with the valve which I believe you showed in that slide, the RA-1238 push-pull valve, to reconnect it so that you can record two independent tracks simultaneously. Have you tried that?

Gerald G. Graham: No, not yet.

Dr. Frayne: It can be done very easily.

Mr. Graham: It's an excellent suggestion.

Dr. Frayne: You merely put the two separate signals on the two outside noise-reduction ribbons, superimpose the noise-reduction currents on these and keep the center ribbon as a mask. You thus get two independent tracks. In the case of variable area, you simply connect each ribbon to an independent signal and noise-reduction input and thus obtain two separate VA tracks.

Mr. Graham: Yes, to date in the experimental work we haven't actually been delving into the recording system. We've tried to work outside of that. That is something we would like to do next.

H. R. Kossman: The speaker mentions making superimposed titles. However, there is another method — it's a Debrie printer which accomplishes this by projecting one single text frame onto the negative while the printer runs. This means a considerable saving in matte costs.

Theory of Parallax Barriers

By SAM H. KAPLAN

The parallax barrier, which is a type of selective masking device now being applied in color television and in stereoscopic imagery, is discussed. A brief history along with the principle and geometric relationship underlying its operation is given. Various systems employing two or more image elements per aperture and utilizing the maximum image area are described. It is also shown that nonplanar and nonparallel arrangements are possible, and that plane barrier surfaces may be coupled to nonplanar image surfaces. Furthermore, lenses may replace the mechanical-type barriers resulting in a more light-efficient system. Formulae are presented and specific applications to multiple-color television tubes are discussed.

A PARALLAX BARRIER may be defined as a masking device which, when interposed between an object space and an image space, prevents any given part of the image space from being sighted from any but a given set of predetermined directions. Since both light and electron beams travel along straight paths, the laws of geometric optics apply irrespective of direction of travel along this path. Consequently, parallax barriers can be utilized where a viewing screen is observed from predetermined directions as in stereoscopic imagery, or where a luminescent screen is impinged upon by electron beams coming from specified directions, as in color television tubes. Parallax barriers are now being used for both of these purposes.

Presented on April 21, 1952, at the Society's Convention at Chicago, Ill., by Sam H. Kaplan, Consultant, 3713 W. Arthington, Chicago 24, Ill.

Brief History

The concept of the parallax barrier is generally attributed to Berthier[1] of France who suggested it in 1896. However it was first applied by Frederick E. Ives[1] to produce stereoscopic still pictures in 1904. These were called "parallax stereograms" and required no separate viewing accessories. The substitution of lenses as an alternate to mechanical blocking barriers was proposed by Gabriel Lippman of France in 1908.[2] A barrier system with more than two elements behind each barrier aperture was invented by C. W. Kanolt who obtained U.S. Patent 1,260,682 on March 26, 1918. His stereoscopic pictures were called "parallax panoramagrams" and revealed a multitude of stereoscopic views as the picture was viewed from different angles. A radial nonparallel-type barrier system was invented by B. T. Ivanof[3] who first

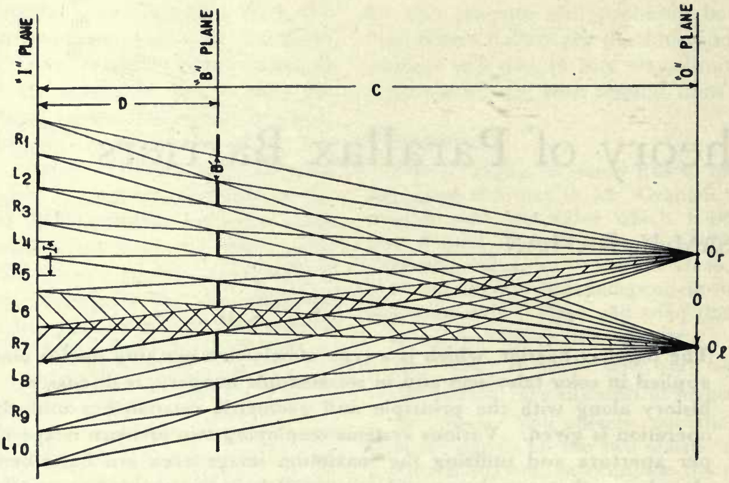

Fig. 1. Two-element barrier.

used it in 1941 to show projected stereoscopic motion pictures in Russia.

The use of parallax barriers as external attachments to cathode-ray tubes for stereoscopic television is included in several patents. The use of such parallax barriers *inside* a cathode-ray tube, as a positive means of insuring that portions of a mosaic screen would be subjected to bombardment only by a predetermined electron beam, was first revealed in German Patent 736,575, issued June 22, 1943. The application date is July 12, 1938, and the inventor was Dr. Warner Fleshig of Fernseh A.G.

Principle and Geometric Relationships

The application of the parallax barrier to stereoscopic pictures can serve to illustrate the principle (see Fig. 1). Two pictures taken from slightly separated points of view and designated as left and right views, are divided into fine strips and reassembled on an alternate basis: R_1, L_2, R_3, L_4, R_5, etc., (the odd numbered L strips and the even numbered R strips are not used). In front of the reassembled picture (labeled "I" plane) there is placed a series of opaque strip barriers separated by transparent strips of equal width (labeled "B" plane). If the barrier is properly located between the picture and the viewer's eyes (labeled O_l and O_r), the left eye will see only the strips L_2, L_4, L_6, etc., (the R strips being hidden by the barriers). Likewise, the right eye will see only strips R_1, R_3, R_5, etc. If the strips are of such small width that they are not individually resolved by the eye, a stereoscopic picture results, since each eye sees only the picture corresponding to its field of view.

From simple geometrical considerations it is possible to determine that the relationship between image distance (D), distance between image strip centers (I), separation of eyes (O), and distance of eye plane to image plane (C), is:

$$D = \frac{IC}{O + I} \tag{1}$$

Although the distance between the eyes (labeled as "O" points) and the image increases steadily in going from the center to the edges of the image, the bandwidth of the picture strips and barrier strips is constant and is independent of the angle between any image

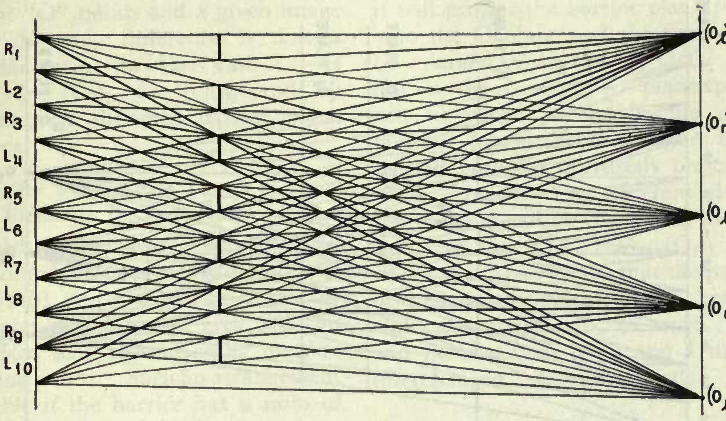

Fig. 2. Two-element barrier showing repeating "O" points.

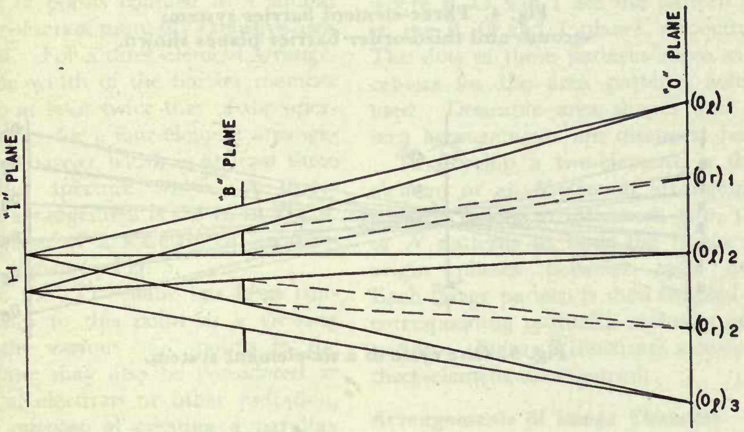

Fig. 3. Alternate viewing of same element by different "O" points.

portion and the line of viewing. Proof is given in an article by C. S. Szegho.[4] The width (B′) separating the barrier strips can be determined from similar triangles to be:

$$B' = \left(\frac{C - D}{C}\right) I \qquad (2)$$

In this case the distance B between barrier strip centers is 2B′.

The question arises whether there are other points in addition to O_l and O_r from which the same picture (i.e., left image seen by left eye and right image seen by right eye) can be viewed. As shown in Fig. 2, by projecting rays from the image through the apertures between barriers, using in turn different barrier spaces for a given image strip, one can obtain an alternating sequence of equally spaced O_l and O_r points. Any combination of O_l and O_r points, whether adjacent or nonadjacent, will fulfill the condition that one "O" point "sees" only one image set and the second "O" point sees the alternate image set. Figure 3 shows in more detail the relationship between these

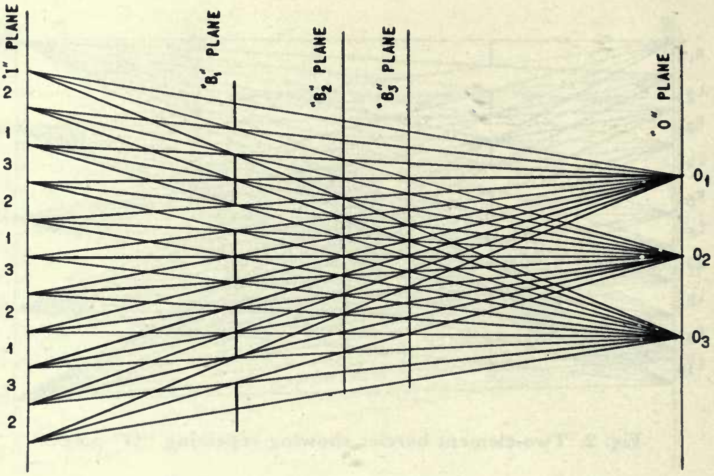

Fig. 4. Three-element barrier system; second- and third-order barrier planes shown.

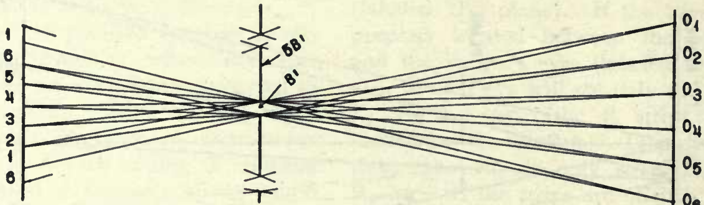

Fig. 5. One cycle of a six-element system.

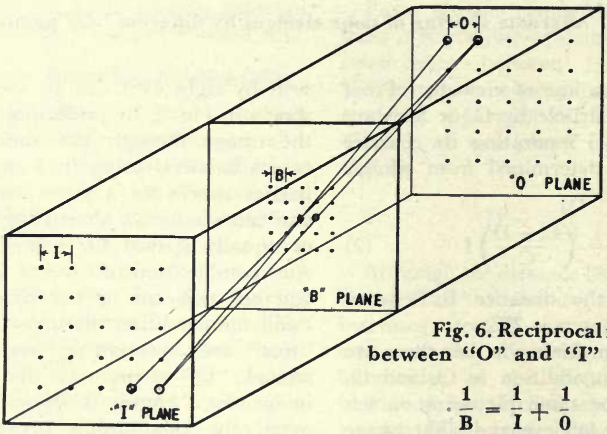

Fig. 6. Reciprocal relation between "O" and "I" planes;

$$\frac{1}{B} = \frac{1}{I} + \frac{1}{O}$$

different "O" points and a given image strip. The only difference is that a particular strip (in this case L_1) is "seen" by $(O_1)_1$, by $(O_1)_2$, and by $(O_1)_3$ through different barrier plane apertures.

Barriers for More Than Two Image Elements per Aperture

Instead of two viewing points (called "O" points) coupled to two mutually intermeshed image area sets, three or more intermeshed image area sets can be coupled to a corresponding number of viewing points. Such an arrangement is possible if the barrier has a ratio of aperture area to total barrier plane of $1/N$ or less, where N equals the number of points coupled to a similar number of sets of mutually exclusive area elements. For a three-element arrangement the width of the barrier member must be at least twice that of the aperture width; for a four-element arrangement the barrier width is at least three times the aperture width. A three-element arrangement is shown in Fig. 4. One section of a six-element arrangement is shown in Fig. 5.

While the "O" plane has been considered up to this point as a viewing plane, the various "O" points in the "O" plane may also be considered as origins of electrons or other radiation, for the purpose of creating a parallax system consisting of an image plane, a barrier plane and an origin (or object) plane.

In order to generalize the theory of parallax barriers, consider the barrier plane to be covered with a regular repeating dot pattern (such as the rectangular dot pattern shown in Fig. 6). If there is a point source of rays in the O plane, the pattern in the barrier plane will be projected on the image plane I and will be enlarged in the ratio of $\left(\frac{C}{C - D}\right)$. If any particular point in the above projected image plane I is considered as an origin, then it will project the barrier plane pattern onto the O plane and the pattern will be enlarged in the ratio of C/D. Any dot in the resulting O plane pattern can be shown to be in the correct position for projection of the barrier pattern onto the previously projected I plane pattern. The different dots in the O plane can be considered to correspond to the $(O_1)_1$, $(O_1)_2$, $(O_1)_3$ points of Fig. 3. Thus we see that the patterns of image and origin planes bear reciprocal relationship to each other, and the functions of O and I may be interchanged. Mathematically:

$$\frac{1}{B} = \frac{1}{O} + \frac{1}{I} \tag{3}$$

where B, O and I are the pattern sizes in the B, O and I planes, respectively. The dots of these patterns serve as the centers for the area patterns actually used. Desirable area shapes and pattern arrangements are discussed below.

To develop a two-element, a three-element or an N-element arrangement, it is necessary to intermesh two, three or N patterns in both the image and origin planes between each other. Each image pattern is then coupled to a corresponding mutually exclusive origin pattern. Figure 7 illustrates a two- and three-element arrangement.

Arrangements of Image Elements

Practical considerations call for the maximum utilization of available area in the image plane. Although many geometrical patterns exist which can cover an entire area, only a few meet the two following criteria:

(1) The patterns must contain only the same shape and size elements.

(2) All the elements must have the same orientation.

Arrangements meeting these criteria are parallelograms (including rectangles and squares) and hexagons. Although an area may be covered by isosceles triangles, such an arrangement does not fulfill the second criterion since

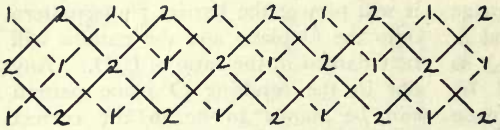

Fig. 7a. Two intermeshed patterns.

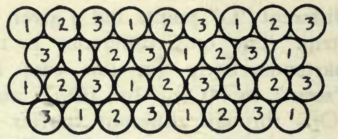

Fig. 7b. Three intermeshed patterns; circle area elements also shown.

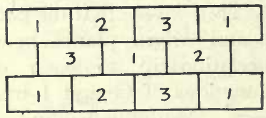

Fig. 8a. Rectangular three-element pattern.

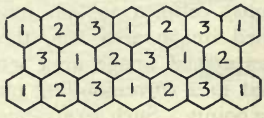

Fig. 8b. Hexagonal three-element pattern.

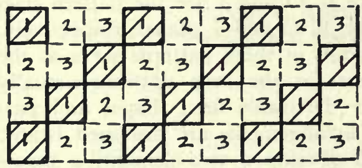

Fig. 9a. Open barrier arrangements, staggered.

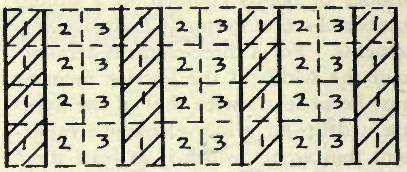

Fig. 9b. Open barrier arrangements, nonstaggered (bands).

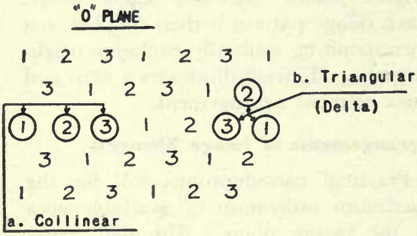

Fig. 10. Preferred three-element origin arrangements.

half the triangles have one orientation and half are oriented 180° out of phase with the first set. From a practical point of view, ellipses (including circles) may be considered to fulfill the necessary conditions, although only 90.7% of the available area is covered when these are in the close-packed arrangement shown in Fig. 7b.

Classification of Barriers

Closed- and Open-Barrier Structures. It is possible to classify parallax barriers with respect to aperture boundaries. The apertures can either meet or not, and the barriers can then be called "open" or "closed," respectively. In the closed-structure type, each aperture is completely surrounded by barrier. Open-barrier structures consist of bands, either straight or staggered.

Three-element arrangements can utilize either open- or closed-type barriers. In order to transform open barriers to the closed-barrier type, alternate image row areas must be staggered 180° with reference to the preceding row. Figure 8 illustrates the image plane arrangement for rectangles and hexagons to go with a closed-type barrier. See Fig. 7b for a similar arrangement for circles. Where rec-

tangles are used and the elements are under one another, only an open-barrier band-type arrangement is possible (shown in Fig. 9).

In the three-element arrangement one origin point is usually selected from each of the three intermeshed O plane patterns. For most purposes it is desirable to choose the O points as close together as possible. The three points may be selected from three adjacent O points in a single line, leading to a "collinear" arrangement shown in Fig. 10a, or the O points may be selected to constitute the apices of a triangle — a "delta" arrangement — leading to an even closer pattern, as shown in Fig. 10b.

Higher Order Barriers. The barriers already described have a reciprocal arrangement between image, source and barrier pattern centers. By looking again at Fig. 4, one may see that there are other possible barrier locations (formed by ray intersections) which fulfill the basic condition of having each image area "seen" by only one of the O points. These locations are shown on the drawing as B_2, B_3, etc. and correspond to the selection of nonadjacent O points from a smaller submultiple O plane pattern. The first barrier plane shown has the O points taken from adjacent points of a pattern having a separation of distance O. The second barrier plane corresponds to the selection of alternate points of a pattern having points separated by distance $\frac{1}{2}$O. The third plane corresponds to the selection of every third point of a pattern with point separation of $\frac{1}{3}$O. This third barrier plane cannot be used in a three-element arrangement since it means all three O points have been taken from the same point set in the O plane, instead of having one O point taken from each of the three intermeshed sets. Each O point would "see" the same image set, and the other two image area sets would be seen by none of the O points. The formula for these other image-to-barrier-plane spacings is given as:

$$\mathrm{D} = \frac{K\mathrm{IC}}{\mathrm{O} + K\mathrm{I}} \tag{4}$$

where K is the ratio of O distance to the smallest O pattern spacing. When using these higher order barriers, the elements of a given image cluster are "seen" by the O points through different apertures, instead of through a single aperture as is the case for the first barrier plane.

Nonplanar Barriers and Images. The parallax barrier principle is not limited to three parallel planes. Consider a spherical surface I and two O points, as shown in Fig. 11a. The locus of the intersections of pairs of rays which are a fixed distance apart on the image surface and pass through the two given O points will sweep out a curve which meets the parallax criteria. This surface will not be a sphere. In this case the size of the elements on the image surface is uniform. By sacrificing this condition, any given barrier B and image I surfaces can be arbitrarily chosen to meet the parallax condition for any given O points. For example, in Fig. 11b, curve I can be a circle (in three dimensions spherical) and curve B may be a plane or a sphere with any given radius. The patterns on I and B must be constructed by a point-by-point method. An example of a two-element construction is illustrated in Fig. 11a. Starting with line 1 connecting O_2 and I_1, draw line 2 connecting O_1 and B_1 (the point of intersection of line 1 and curve B), continuing on to curve I. Line 3 then connects O_2 and I_2 (the point of intersection of line 2 and I). Line 4 connects O_1 and B_2 (the point of intersection of line 3 with B), etc. In other words, O_2 lines connect with previous intersection points on I and O_1 lines connect with previous intersection points on B. The examples are shown in two dimensions. The three-

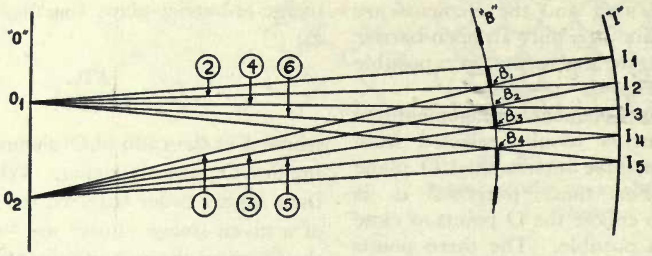

Fig. 11a. Construction of spherical "I" and "B" surfaces, nonuniform elements.

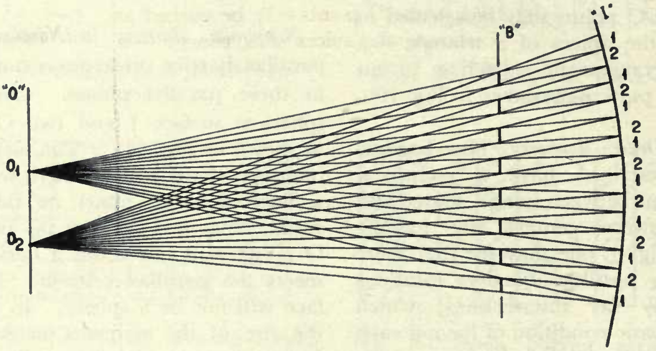

Fig. 11b. Spherical "I" and plane "B" surfaces.

dimension arrangement necessary for any practical use is more complicated.

The above analysis is based upon a 100% utilization of available image area. It may be desirable to have both fixed surfaces of given shapes and a uniform pattern on one of the surfaces. This can be done, but only by sacrificing some of the image area. For example, the surface I can be chosen as spherical, and the barrier surface as a plane with a uniform dot pattern. This can be done if the aperture size in the plane barrier is small enough to avoid overlapping patterns on surface I.

The Radial-Type Barrier. If the image, barrier and source surfaces are planar, they need not be parallel. The above principles can be used to generate nonparallel arrangements. One such arrangement of interest is the radial plane arrangement, invented by Ivanof and used for stereoscopic pictures. As shown in Fig. 12, all three planes meet in a common line of intersection and all band patterns of I, B and O planes converge toward a single point on this common line of intersection. For motion pictures—the I plane comprises the screen; the B plane, the parallax barrier; and the audience, the O plane. This arrangement permits a large number of seats to satisfy the parallax condition, in contrast to the parallel plane arrangement where only one row in the theater can meet the necessary condition. Of course, if the rows could be stacked vertically instead of horizontally then the parallel plane arrangement would be suitable.

The Venetian-Blind Barrier. Instead of a separate barrier plane, the surface itself can be shaped to provide the

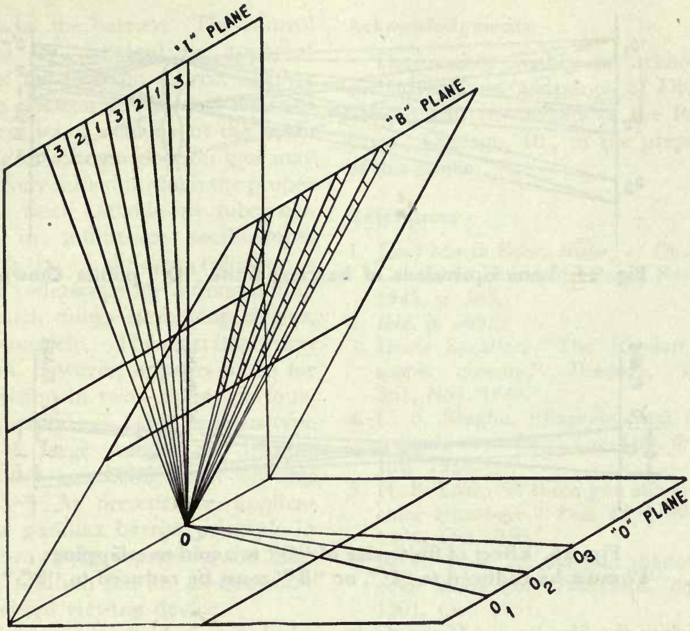

Fig. 12. The radial barrier arrangement.

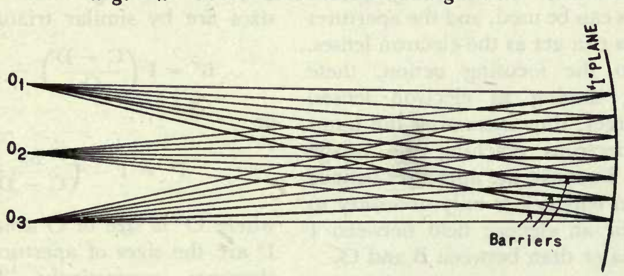

Fig. 13. Venetian-blind barrier.

necessary parallax condition as shown in Fig. 13. The sides of the slats form two of the three image areas. The surface now resembles a venetian blind. The height of the slats is equal to the distance D as in the other arrangements and is determined by the construction methods and formulae already given.

Physical Limitations and How to Minimize Them

Light Loss Caused by the Barrier. One defect in the practical application of parallax barriers is the transmission loss introduced by the barrier itself. This limitation can be minimized by replacing each aperture or slit by a spherical or a cylindrical lens, as shown in Fig. 14. Replacing the aperture by a larger size lens can theoretically cut the barrier loss to zero. Instead of acting as a mechanical barrier, the lenses refract or converge the rays to the proper position on the image surface. In stereoscopic picture processes modern practice calls for cylindrical lens elements

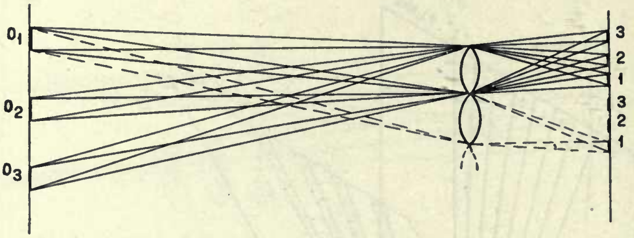

Fig. 14. Lens equivalent of barrier; finite "O" points shown.

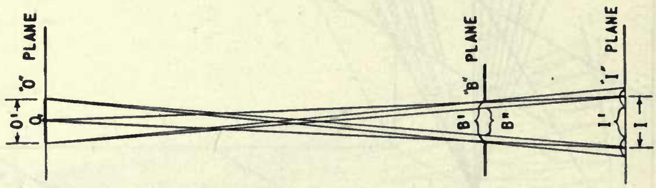

Fig. 15. Effect of finite size of "O" to avoid overlapping; "I" must be reduced to "I′", or "B′" must be reduced to "B″."

molded into the film base. If one deals with electron rays instead of light, electron lenses can be used, and the apertures themselves can act as the electron lenses. Owing to the focusing action, these apertures, serving as electron lenses, can be larger, thus increasing the number of electrons reaching the image plane I. To make the apertures behave as electron lenses, it is only necessary to provide for an electric field between I and B greater than between B and O.

Finite-Area Sources. All previous discussion has been on the basis of point sources in the O plane. Actually, especially in electronic apparatus, the O points have appreciable area. In order to ensure that each O point sees only its own image plane patterns when using barriers (rather than lenses), it is necessary (see Fig. 15) to reduce either the size of the barrier plane apertures B′ or the size of the image plane elements I′, in either case maintaining the same separation distance between apertures and image elements. Figure 15 shows the proper geometrical solution to achieve the nonoverlapping condition of image areas. The reduced sizes are by similar triangles:

$$B'' = I\left(\frac{C - D}{C}\right) - \left(\frac{D}{C}\right) O' \qquad (5)$$

or

$$I' = I - \left(\frac{B'}{C - D}\right) O' \qquad (6)$$

where O′ is size of O area and B′ and I′ are the sizes of apertures and image elements, respectively. The reduced B″ or I′ size will result in loss of efficiency by reducing the number of rays from the O points which can be utilized.

Practical Application of Barriers in Cathode-Ray Tubes

The parallax barrier is particularly suitable as an internal member in cathode-ray tubes, permitting positive screen area control and ensuring that a given beam impinge only on a given portion of the fluorescent screen. Specified screen areas are associated with a desired source of electrons, and electrons from other sources are blocked from the

same area by the barrier. The control is effected by the real or apparent position of the electron source. Either a separate electron gun is used for each independent set of elements or the beam originating in a single electron gun may be successively shifted through the proper O points. Such cathode-ray tubes can be used in multitrace oscilloscopes giving each trace a different color, or as multicolor radarscope for differentiating by color such things as moving targets, radar beacons, etc. The most important application, however, appears to be for color television in two-, three- or four-color sequential or simultaneous-type systems. A large number of tricolor picture tubes are being built on this principle.[4,5,6] At present the application of the parallax barrier principle in a cathode-ray tube represents the most promising solution for an all-electronic color television viewing device.

Acknowledgments

The author wishes to acknowledge the advice and assistance of Dr. C. S. Szegho and co-workers of the Rauland Corp., Chicago, Ill., in the preparation of this paper.

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New Direct-Vision Stereo-Projection Screen

By W. WHEELER JENNINGS and PIERRE VANET

This paper discusses the development of a new direct-vision stereo-projection screen. It permits the audience to see three-dimensional color motion pictures and slides without the aid of conventional polarized viewing glasses.

For more than half a century, thousands of dollars have been invested by researchers in the hope of developing a good commercial free-vision stereo-projection screen. The problems encountered have been very complex.

First, let us re-examine the mechanism of our visual impressions. We see objects in relief because of the perception of each of our eyes of a point located in space and observed at different angles that correspond to the distance between the eyes (Fig. 1). The convergent action of our eyes enables us to estimate by exploration the various distances of different points located in space.

The image received on the retina of the right eye is not the same as received by the left eye. In order to get the impression of relief, it is necessary to project two views taken at different angles and to avail oneself of means that will enable each eye to see only the picture it should receive at the exclusion of the other.[1]

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by W. Wheeler Jennings, 7549 South Clyde Ave., Chicago 49, Ill., and Pierre Vanet, Societe des Anciens Etablissements, A. Mattey, Paris, France.

In order to get natural binocular vision under our existing stereo-projection processes, it is necessary for the spectator to wear special polarized or red and green viewing spectacles.

We will deal here only with the processes of stereo projection that give us directly and collectively three-dimensional screen images as seen with our natural vision.

The Noaillon Theory

In 1928, Professor Noaillon, of Brussels, Belgium, developed a selector system, made up of radial converging lines in the form of grills with very wide openings. This system consists of three reclining grills shaking or oscillating in their own plane around their meeting points, as shown in Fig. 2.

Figure 3 shows projection on screen E through this radial-lined network which determines the selective vision surfaces. Starting from the stereo-projector G and D, representing the left and right stereo images, the projected image travels to the meeting point O

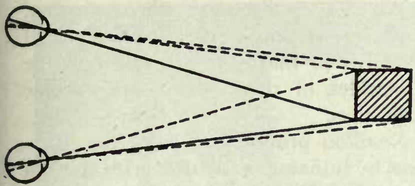

Figure 1.

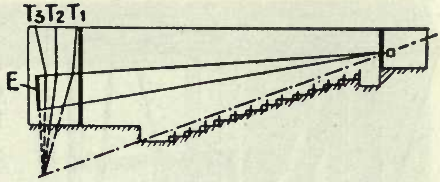

Figure 2.

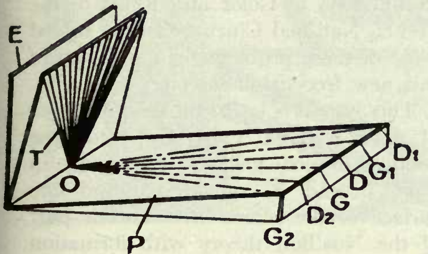

Figure 3.

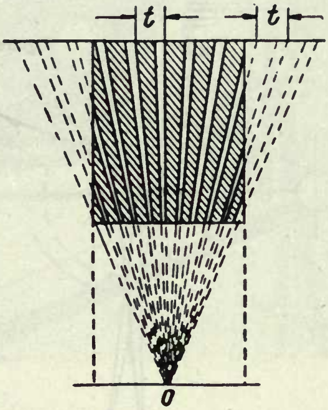

Figure 4.

of all the lines T of the converging grills. Direct-vision zones G2, D2, G1 and D1 radiate on surface P. The convergent setting of the selector grills brought an important improvement in the projected stereoscopic vision of depth.[2]

The Findings of Russia's Ivanov

In 1945 and 1946, we had newspaper reports of excellent 35mm stereo motion pictures and free-vision theater projection in Moscow. Much of the information sounded far-fetched, especially concerning the technical means employed.

Since that date, a translation from the Russian reveals most of the steps used in their process: The screen employed was of lined network design converging, similar to the Noaillon theory shown in Fig. 2 and 3, but Ivanov's network is stationary. This weblike network shown in Fig. 4 consists of more than 30,000 white enameled wires stretched from the top of the screen T to the meeting point on the bottom O. The shaded portion is the projected picture area. These wires pull a total tension of 30 tons. The total weight of the screen is approximately 6 tons. Figure 5 is a schematic of Russian origin showing the vertical screen format of the split frame. The stereo-screen image is estimated to be approximately 12 ft × 9 ft. Because of the very narrow and limited vision zones, the theater in which this screen is installed seats only 250 people.

According to Ivanov, the theory of Noaillon brought out the following defects: (1) considerable absorption of light and (2) a very narrow observation zone, which does not allow the spectator to move his head. These are

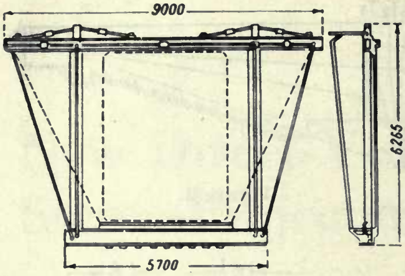

Figure 5.

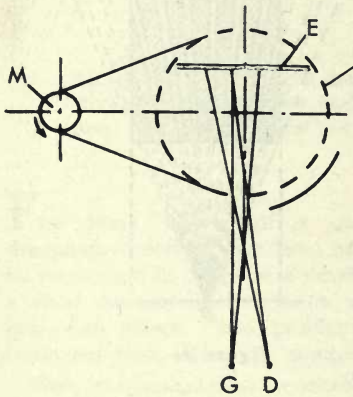

Figure 6.

all faults common to methods using the fixed stretched network screen.

In an attempt to remedy these faults, the Russians sought to achieve a selector system consisting of conical converging diopters. Unable to achieve the diopters mechanically by means used in optics, they tried to obtain the results by photographic means, probably by utilizing the properties of bichromate on the film emulsion, which permits an apparent relief.

Nevertheless, the Russians have made a careful study of the momentous problems of stereoscopic motion pictures, but they have struck a technical impossibility in realizing a suitable selector of transmission that does not produce the faults of light absorption and diffraction already discussed.

We have discussed the principal obstacles stopping the use of lined networks so that you will know of the difficulties of direct-vision stereoscopic projection.

Noaillon proposed to solve the problems by utilizing oscillating grills starting with a selector system with much larger openings between grills, which simplifies the construction of the stereoscopic network.

A New Direct-Vision Stereo-Projection Screen

Francois Savoye, member of the Commission of Color and Relief of the French National Cinema Centre, solved some of these problems in the design of this new free-vision screen.

This system is based on the properties of stereo-selection given by a rotating conical shaped grill T as shown in Figs. 6 and 8, moving around the surface of the screen E. This is part of the Noaillon theory with formation of converging zones, on the plane perpendicular to the plane on the screen. This device enables the collective direct-vision of stereoscopic pairs.[3] The impressions of relief are obtained in the same manner as by natural vision. Each spectator sees the right picture D for the right eye and the left picture G for the left eye. The rotating grill driven by motor M produces total shading, by persistence of vision sweeping the screen, thus showing the whole picture with all its detail in color or black-and-white.

Figure 7 shows a 5-ft screen with a projected stereo-image. This was photographed with a stereo-camera from the spectator's seat.

For the sake of simplicity, we will describe the engineer's model. The revolving grill in Fig. 8 is constructed of 108 aluminum bars forming the conical section. The top support of the cone is 36 in. in diameter. This accommodates a beaded screen 18 in. × 24 in. Each bar is set on geometric lines at

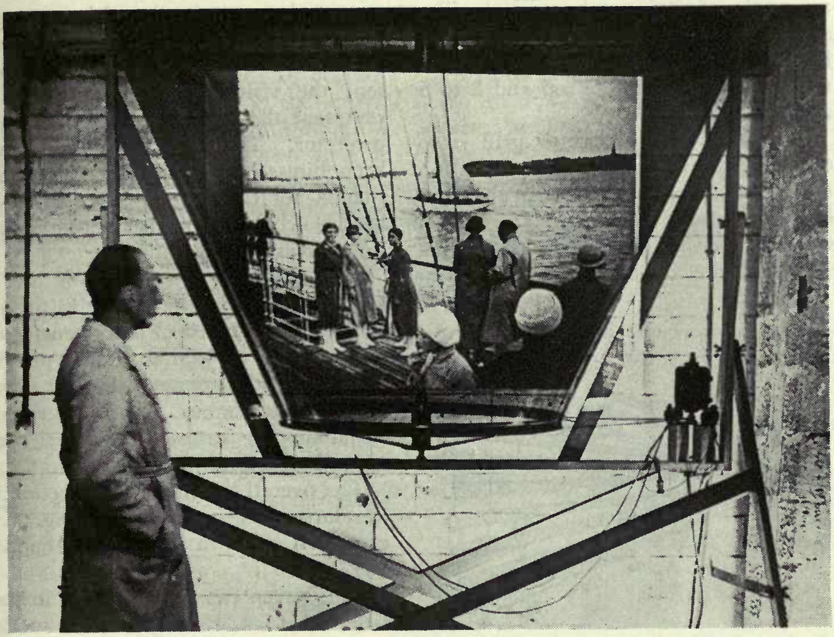

Figure 7.

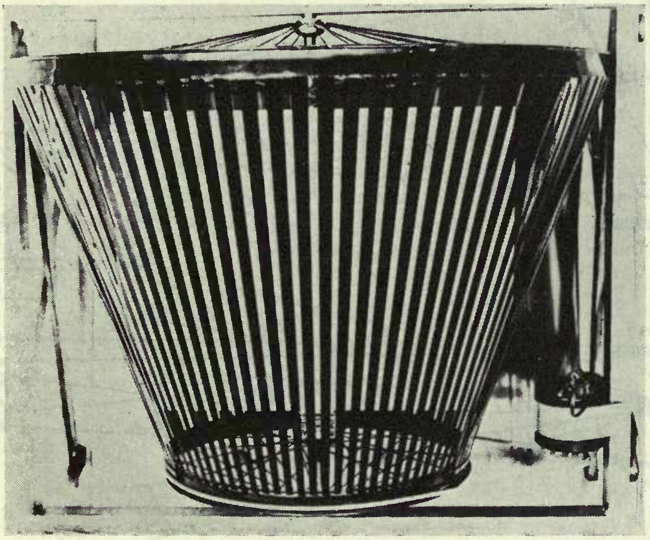

Figure 8.

an angle of 20° to the screen. The spacing must be accurate and the ratio between the opening and the width of the bar is 3 to 5 at the top and 2 to 5 at the bottom.

The path of the selector grill is so designed as to have zones of vision every four degrees as shown in the seating arrangement in Fig. 9. The correct viewing distance is $2\frac{1}{2}$ to 6 times the width of the screen. It is simple to pre-set the seats in the vision zone of 40°. R1, R2, R3, R4 and R5 represent the rows of seats. G and D represent the vision zones. OG and OD represent the two images of the stereo-projector. The spectator will naturally keep himself in a suitable vision zone that is not rigid, so he may move his head slowly until the visual accommodations are most favorable.

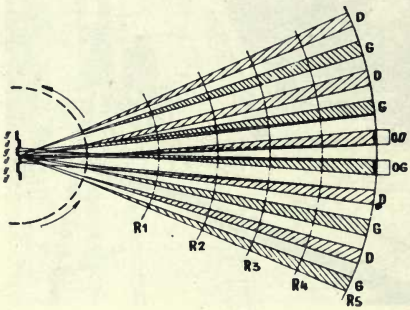

Figure 9.

The direction of rotation of the selector grill is from left to right, turning at a constant speed of four turns a second. When projecting motion pictures it was found necessary to use a synchronous motor to turn the grill, to eliminate any stroboscopic interference with the projector's shutter.

The overall light-loss in projection on the large screen shown in Fig. 7 is estimated to be in the neighborhood of 50%.

This screen can be fabricated in most sizes up to a 10-ft grill. We understand, Mr. Savoye is now engineering

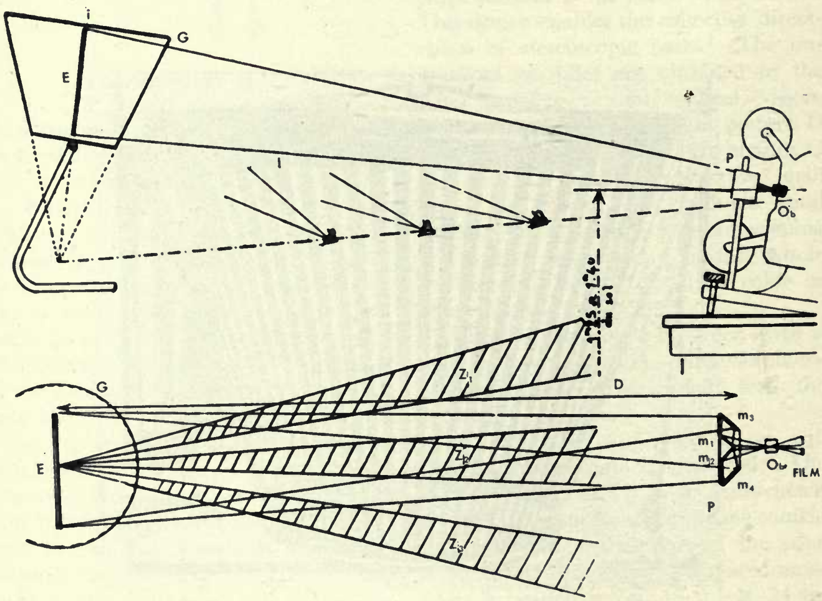

Figure 10.

a theater-size screen for an auditorium seating 500.

The projector must be located behind the spectator as illustrated in the upper half of Fig. 10. When projecting a very short distance, the screen should be tilted forward about 5°. The lower half of Fig. 10 illustrates the projection of stereo-pairs from a single film by the use of beam-splitter P mounted on the front of the projector lens. The vision zones Z1, Z2 and Z3 are the same as shown in Fig. 9.

We will not attempt to discuss the various types of beam-splitters and lenses used in taking and projecting 16mm and 35mm motion picture stereo-pairs. This is a specialized technical subject that requires individual treatment.

There is a great interest in color stereo motion pictures. They have a definite application in the fields of education, industry and science. Everywhere three-dimensional color motion pictures have been exhibited, they have had a tremendous audience appeal.

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Automatic Torque Controller for Torque Motors

By CARL E. HITTLE

The use of the automatic torque controller permits the full advantages of torque motors to be realized for film take-up and holdback duty without being handicapped by their inherent limitations when operated in the conventional manner.

Since the first sound-on-film recording and reproducing units were made, many types of film-spool drives have been used on such apparatus. During the intervening years, film-spool drives ranging from the slipping belt to friction clutch, and, more recently, to torque-motor types have been used. When torque motors became available it was believed that they would provide the ultimate in performance, possessing more advantages than the previous types of drives and none of the disadvantages. Experience with these motors taught us that in the latter respect this was not true. As with the belt and the friction clutch drives, we found that torque-motor drives may also adversely affect the steadiness of film motion in the apparatus. Since the characteristics of torque-motor drives in connection with their use for take-up and feed spools in film-pulling mechanisms have been presented previously before the Society in a paper by A. L. Holcomb,* only the manner in which they may affect film motion will be reiterated. As stated in Mr. Holcomb's paper, these adverse effects may result from the following:

1. Sprocket-hole flutter (96 cycle/sec) due to high film tension at beginning or end of a reel.
2. Erratic shifting of the film with respect to the sprockets at "crossover" where the net tension on the film reverses.
3. Gear train chatter due to unloading the sprocket gears at crossover.

All of these contributing factors may be eliminated by maintaining constant film tension throughout the roll between each film spool and film sprocket with a differential in tension between

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* A. L. Holcomb, "Film-spool drive with torque motor," *Jour. SMPTE, 58:* 28–35, Jan. 1952.

the take-up side and the drag side, tension on the latter side being of lesser numerical value. Film tension may be controlled and maintained within satisfactory operating limits by means of the automatic torque controller for torque motors to be described herein. It is equally useful whether the motor is used as a take-up or drag device. The principle of operation of the controller

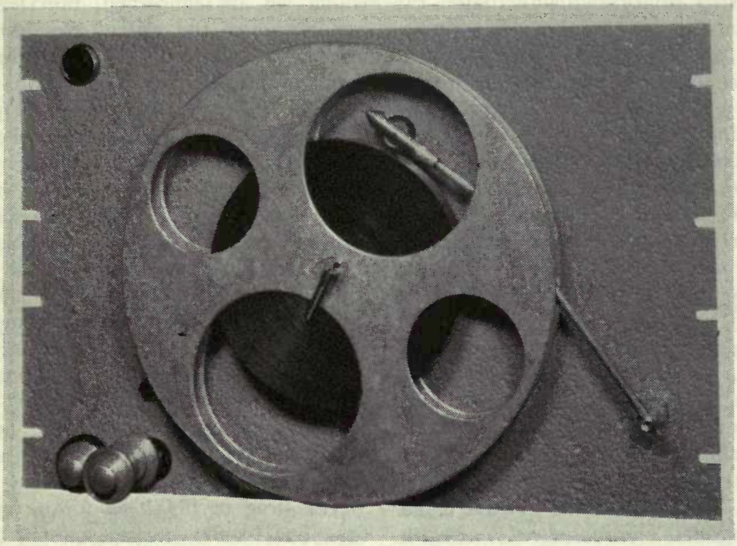

Fig. 1. Torque Controller — front view.

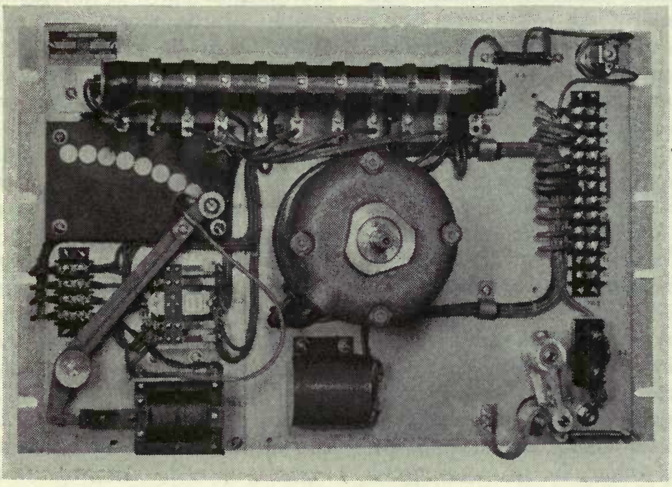

Fig. 2. Torque Controller — rear view.

is based on the fact that the torque produced by the motor may be varied by changing the voltage to the motor.

Principal elements of the controller consist of the following: a film roll follower mounted on a rotatable arm, a multistep rotary switch actuated by the rotatable arm, a set of resistors having as many adjustable contact bands as there are steps on the rotary switch, a solenoid, a relay, and interconnecting wiring.

The film roll follower arm assembly is mounted on the front side of the reel panel as shown in Fig. 1. The remainder of the mechanism is mounted on the back side of the panel together with the torque motor.

When used in conjunction with the motor serving to drive the take-up spool or reel, the device functions in the following manner. Sufficient resistance is introduced in series with the motor at the start of the roll during take-up to reduce the film tension to the desired value. Thus the usual initial high film tension is eliminated at the beginning, thus removing this cause of sprocket-hole flutter. The torque controller functions in a manner to maintain film tension relatively constant. As the diameter of the roll of film being wound on the take-up spool increases, the roller on the follower arm is moved farther from the center of the spool, causing the shaft to which the arm is attached to be rotated. The rotary switch contactor arm, mounted on the opposite end of the shaft, is moved gradually across the step contacts of the switch shown in Fig. 2. Sufficient free movement has been provided in the mechanical assembly to prevent rotational eccentricity of the roll of film from causing oscillation of the contact brush across adjacent switch steps. The gradual operation of the rotary switch causes small incremental decreases of resistance in the motor circuit resulting in a gradual increase in motor voltage. This, in turn, due to the electrical characteristics of the torque motor produces an increase in motor torque.

As applied herein, torque may be defined as the product of a force multiplied by a moment arm. In terms with which we are concerned, film tension and radius of the roll of film are the force and moment arm members, respectively, of the torque equation.

With proper adjustment of the positions of the resistor contact bands, the torque may be controlled so as to maintain the film tension constant within approximately 2 oz. Based on a normal tension of 11 oz, the 2-oz variation is less than 20% deviation. Should one attempt to use 2000-ft rolls with standard 2-in. film cores on apparatus equipped with friction clutch or standard torque-motor take-up drives, the deviation would be on the order of 600%. This deviation in tension would be nearly 400% for 1000-ft rolls under the same conditions.

The drag or holdback torque motor functions in the inverse manner from that for take-up. To prevent freewheeling of the roll of film with the motor power off, a friction clutch is incorporated in the mechanical assembly of the motor and reel shaft. Since this available friction is sufficient to provide holdback as the diameter of the roll of film approaches the core, motor power is turned off when the roll is reduced to a predetermined diameter. This is accomplished by means of a relay, shown in Fig. 3, which is energized from the main motor switch that controls the direction of film travel through the apparatus. When the relay is energized, the electrical connections between the last two steps of the rotary switch and their associated resistor contact bands are opened. Then, when the rotary switch arm contacts either of these two steps, the electrical circuit to the motor is opened. Also, when energized, the relay causes additional resistance to be imposed in the electrical circuit to

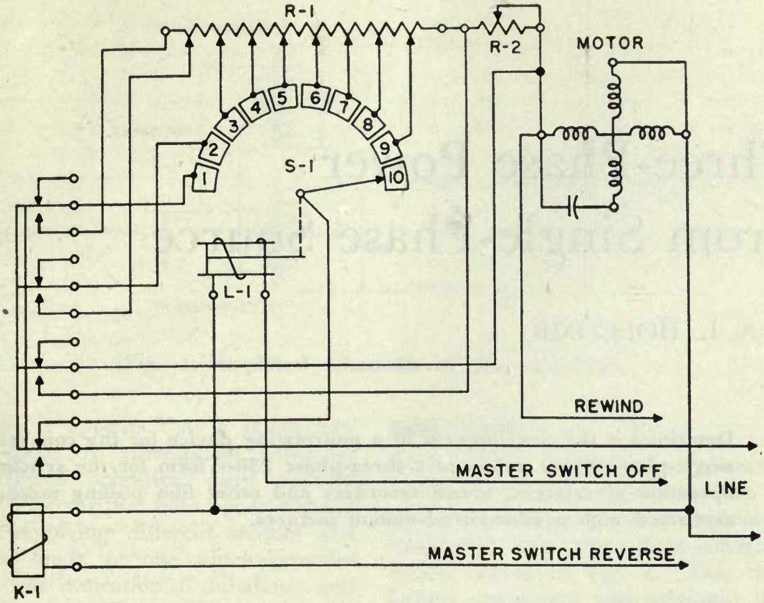

Fig. 3. Schematic diagram of Torque Controller.

obtain the decreased torque required when the motor is used for holdback. Operation of the device in the above manner serves to maintain a lower value of film tension for holdback operation than for take-up with no change required in the settings of the resistor contact bands for change-over from take-up to holdback duty.

Maintenance of holdback tension in proper relation to the take-up tension results in the elimination of: (1) reversal of the net film tension and its resultant shifting of the film on the sprocket plus gear train chatter, (2) high film tension at the end of the reel which otherwise would tend to produce sprocket-hole flutter.

An automatic follower arm lift has been provided to facilitate placement of a reel or spool of film on the reel spindle or removal therefrom. Lifting of the arm to its extreme rotational position from the spindle is accomplished by means of the solenoid, shown in Fig. 3, which is energized when the main motor power switch is in its OFF position.

The automatic torque controller as illustrated is suitable for use on magnetic recorder-reproducers or photographic reproducers having film handling capacity on either reels or spools up to 2000 ft. Its use is particularly advantageous in eliminating the extremely high film tension which results when 2000-ft rolls wound on standard film cores are used. Obviously the same principle may be applied for reels of larger diameter.

Three-Phase Power From Single-Phase Source

By A. L. HOLCOMB

Described is the development of a nonrotating device for the conversion of single-phase 115-v power to a three-phase 230-v form for the synchronous operation of cameras, sound recorders and other film pulling mechanisms associated with production of motion pictures.

THREE-PHASE MOTORS provide several desirable characteristics which are not supplied by single-phase units of equivalent power, and these characteristics, which include smaller size, lighter weight and quieter performance, are of particular value for the operation of cameras in motion picture production. Unfortunately, three-phase power lines are seldom available for location work outside of the studio lot, whereas the single-phase, 115-v source has become readily available in a large percentage of locations. Since sound recorders can conveniently be driven by single-phase motors, due to higher permissible noise, and to less rigorous weight-space requirements than cameras, it has become apparent that a synchronous converter from single-phase, 115-v, to three-phase, 230-v, for camera operation would be a desirable device. This would permit the operation of all channel equipment from a single-phase source without degrading camera performance.

A nonrotating device is preferable for reasons of noise and maintenance and while several such units are commercially available for this duty, they are not well fitted for camera drive since they require factory adjustment for the particular motor and load which the unit is to supply. Operation with other motors or different loads causes phase unbalance which can create operating noise and/or limit the maximum power obtainable from the motor, thus destroying the very features for which a three-phase motor is desirable. Since most cameras used in motion picture production vary widely in power demand with temperature change, it is only by chance that the factory adjusted phase balance is optimum for any given location condition. If the maximum power condition of the motor is selected for phase balance, an unbalance and noisy operation exist for all lesser loads while adjustment for balance at light load reduces the maximum power obtainable.

Presented on April 25, 1952, at the Society's Convention at Chicago, Ill., by John G. Frayne for the author, A. L. Holcomb, Westrex Corp., 6601 Romaine St., Hollywood 38, Calif.

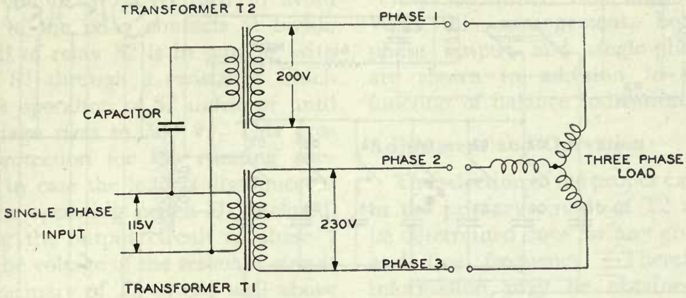

Fig. 1. Simplified schematic of the Converter.

Thus, it appears that a satisfactory single-phase to three-phase converter for camera operation must provide either a circuit that does not unbalance when supplying different motors and varying loads, or one which provides some clear indication of unbalance and a ready means of correction which is not too complicated for field adjustment.

Consideration of the problem indicates that the required phase shift from two conductors electrically 180° apart to three conductors displaced 120° cannot be obtained on a nonrotating basis without introducing reactance in various forms in the conversion circuit. Since the electrical load is also reactive, it will combine with the circuit reactance to determine the phase shift obtained unless isolation can be introduced between the conversion circuit and motor. Adequate isolation does not appear to be practical because of space-weight and efficiency factors and thus the motor reactance which varies from motor to motor and with load on any given motor must be considered as a component part of the conversion circuit. Therefore, a conversion circuit which will inherently maintain phase balance in the presence of the prescribed conditions is not considered practical, and as a result development has been focused on the alternative method, which would provide convenient indication and adjustment.

Basic Circuit

The Scott transformer connection, which is relatively old in the art and described in most electrical engineering handbooks, is the basis of the conversion circuit shown in Fig. 1. This transformer connection was originally used for the conversion of two-phase to three-phase or vice versa. By the addition of a capacitor of the right value in series with the primary of transformer T2, as shown in Fig. 1, the current in this primary can be shifted 90° with respect to the primary of T1 and thus the equivalent of a two-phase primary circuit is provided from a single-phase source. In the secondary, a three-phase electrical displacement exists only when connected to a balanced three-phase inductive load, which is the load condition presented by a three-phase motor.

The circuit functions to produce 120° phase displacement between the three output leads by means of the vector addition of both a proper voltage and a 90° phase shift with respect to the mid-tap of T1. A portion of the inductive load is reflected through T2 where it is effectively resonated at line frequency by the series capacitor. This provides the 90° phase shift mentioned, since at resonance there will be no reactive component in the primary of T2 and the current will be in phase

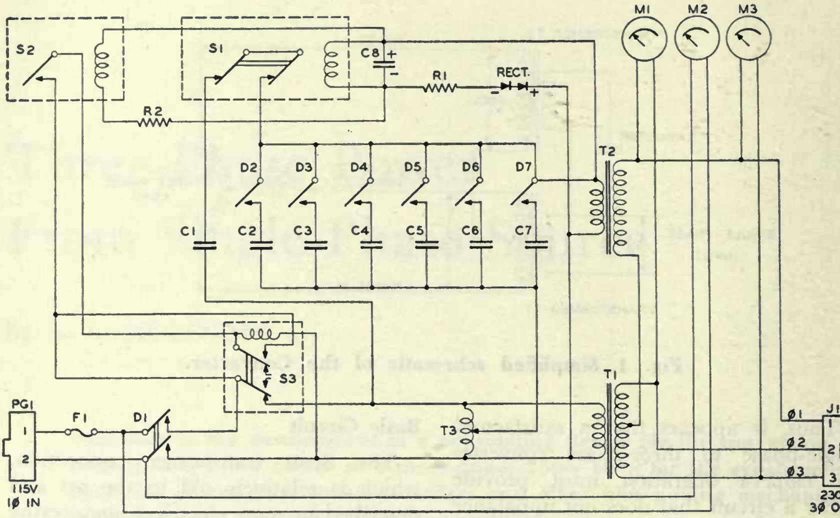

Fig. 2. Schematic of the Converter.

with the voltage. The current in the primary of T1 will lag approximately 90° since it is predominantly inductive. The secondary voltages of T1 and T2 will thus be 90° out of phase and if the secondary voltage of T1 is made 230 v and that of T2 is 200 v, then the voltage between the lead marked Phase 1 and either Phase 2 or 3 will be: $E_{T1/2} + jE_{T2}$ or 230 v. As combined in the load, the currents in all three phases are approximately 120° apart.

From the above it becomes apparent why such circuits require adjustment to a specific load condition since a variation in either phase or voltage of the secondary of T2 will upset the three-phase balance and both factors will vary with any change in impedance or inductance of the load. It also becomes apparent that this correction must provide a separate adjustment of the capacitor to match the load inductance in addition to a voltage correction for T2.

Developed Circuit

Development of the basic circuit for actual use is shown in Fig. 2. The transformers T1 and T2 appear in the same form as in Fig. 1, but the single capacitor is replaced by six units (C2 to 7) of such sizes that they provide any value from 1 to 60 μf in 1-μf steps and are readily connected as required by means of individual switches. These are oil filled a-c capacitors rated at 330 v. An additional capacitor shown as C1 is an a-c electrolytic unit of 100-μf capacity normally connected in parallel with the others through the relay S1. This is a necessary feature since the impedance of a synchronous motor is very much lower at the instant of starting than when running; therefore, the capacitance required to approach resonance at line frequency is several times greater at start than is desirable for running phase balance at even maximum load. Unless this initial high capacitance is provided, the output is essentially single-phase and the motor will not start. C1 meets this condition for the short start time and is automatically disconnected by the relay S1 when the voltage across the primary of T2 reaches 100 v. The current supply

to the coil of S1 is rectified to avoid chatter of the relay contacts at break. The coil of relay S2 is in parallel with that of S1 through a resistance which prevents operation of S2 unless or until the voltage rises to 300 v. This provides protection for the running condensers in case the load is disconnected while the operating switch D1 is closed. Opening the output circuit of phase 1 allows the voltage of the resonant circuit in the primary of T2 to rise well above the condenser rating unless this protection is provided. S2 in turn operates the relay S3 which opens the input circuit and locks up in this position until the input potential is removed.

Tap changing on T2 was considered as an alternative method of resonating the primary with a single condenser, but this was abandoned since tap changing in such a resonant circuit causes excessive arcing, and because adjustment equal to that obtained by six condensers and switches would require a sixty-point tap switch.

Voltage adjustment for T2 may be obtained without phase shift by means of series resistance in the resonant circuit or by resistance shunted across the primary of T2, but either method results in serious I^2R losses. The Variac T3 when connected across the input line, as shown, functions as an efficient voltage divider and does not contribute a reactive component to the resonant circuit since the exciting current is supplied by the line. Also, the range of adjustment is wide and very smooth.

The three small voltmeters M1, 2 and 3 are the indicators used to determine and maintain phase balance. M2 is a 150-v meter connected across the incoming line which serves as a pilot meter on the single-phase supply, and also effectively indicates the voltage across phase leads 2 and 3 during operation since this voltage is twice the line voltage except where a heavy load may introduce appreciable I^2R loss in T1. M1 and M3 are 300-v meters across the other two output phases. With this arrangement, both three-phase output and single-phase input are shown in addition to the basic function of balance indication.

Adjustment and Operation

The selection of the proper capacitance in the primary circuit of T2 need only be determined once for any given motor and line frequency. Therefore, this information may be obtained in the shop before the camera goes on the set or location. Once obtained, the condenser values for different motors, or combinations of motors, may be tabulated and attached to the converter for ready reference.

To determine capacitor value, the motor is connected for operation, preferably driving a camera or other normal load. The condenser values of 1, 2, 4, 8, 15 and 30 μf are marked on the plate adjacent to the switches which connect them in parallel. Thus, the values shown are additive as the switch handles are toward the marked plate. About 25 μf should be connected as a preliminary value of capacitance for 60-cycle operation (approximately 35 μf for 50-cycle). The Variac is positioned about center and the motor started by closing the "line" switch D1. The two outside meters M1 and 3 are then observed and the Variac adjusted until they read alike. If this balanced reading is higher than the pointer position of the middle meter M2 (twice the indicated voltage) then the capacitance should be reduced, or vice versa, and M1 and 2 again balanced by Variac adjustment. This is continued until all three meters show the same pointer position. With very little practice this adjustment can be accomplished in less than a minute. Having established and noted the capacitor value the unit is ready for operation; further adjustment for load variation being made by changing the Variac to make the pointer of M1 read the same as

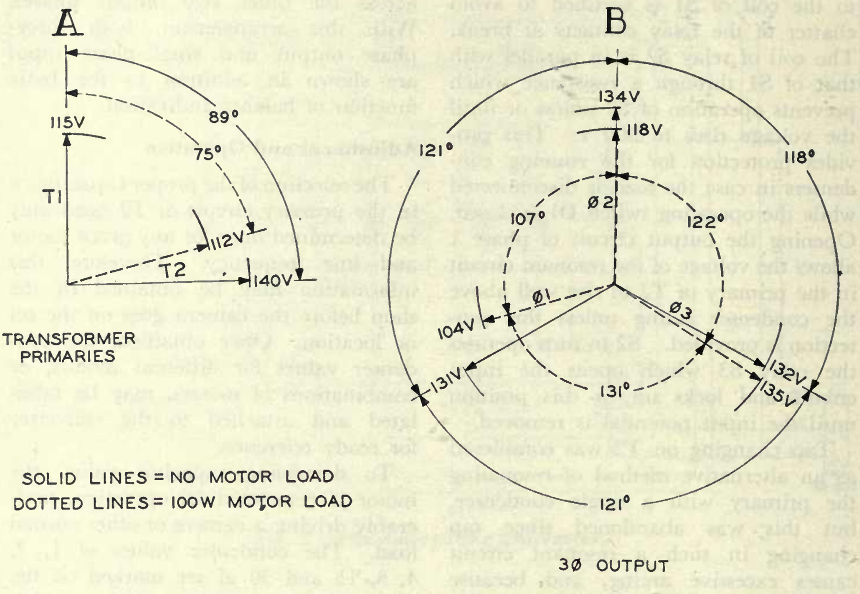

Fig. 3. Phase-voltage relations — without load correction.

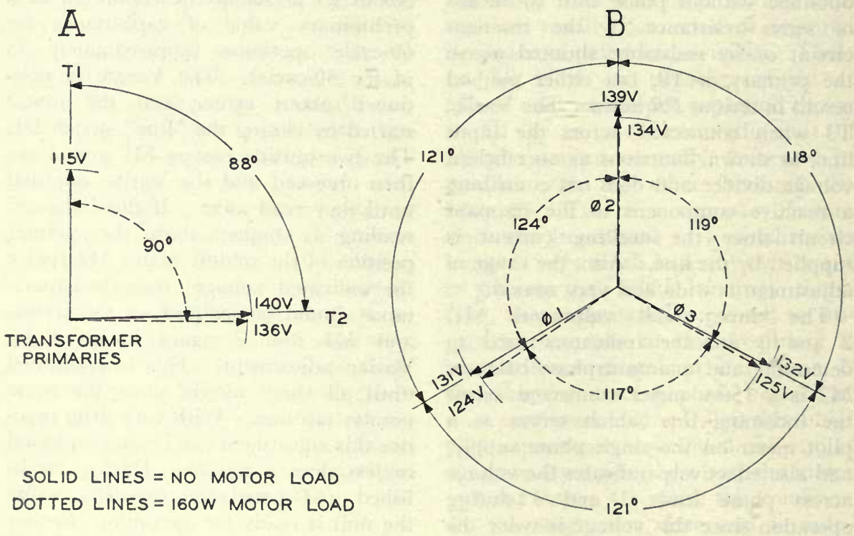

Fig. 4. Phase-voltage relations — with load correction.

M2 ± a few volts. In either initial or subsequent balancing, it will be found that both M1 and M3 vary in the same direction with each other and with the Variac. However, M1, across phase 1 and 2, varies more rapidly than M3, and M2 does not change except with input voltage.

In operation, the converter may be located at the camera and the "line" switch D1 used as the camera operating switch, or the unit may be positioned at the recorder with any individual or common switching desired. In mild weather where temperature and camera load do not vary greatly, the initial load adjustment of the Variac might well remain the same for several days shooting. In case of cold weather, however, some cameras will warm up enough in a long take to change load by a factor of 2 or 3. Adjustment of the Variac to meet this condition may be made during a take without disturbance to either picture or sound. It should be noted, however, that precise adjustment is not essential to operation and under average conditions the unit can be forgotten unless the camera motor becomes noisy or lacks power.

Where recorder and camera are both operated from the converter, either motor may be dropped off at will. The phase balance will be materially upset and the remaining motor will be noisy but the recorder is usually too far from the microphone to cause trouble, and if the recorder is cut off, the camera noise does not matter.

Performance

It is obvious that the voltmeters used as indicators of phase balance actually show only voltage across the three phases and indicate phase relation indirectly if at all. Thus, this method of indication may well be questioned. Since the voltages indicated are each a resultant of two voltages to the mid-point of the load, which in turn are the resultant of a vectorial addition of both voltage and phase relation, the theoretical reasons why such indications are of value become involved and tedious and will be omitted in favor of measured results.

A true picture of the voltage conditions in the load can be obtained by measuring the voltage from each phase lead to a mid-tap on a star connected load. In addition, a method was devised which indicated voltage phase relations across the same points, and across T1 and T2 primaries, to an accuracy of $\pm\frac{1}{2}°$. The currents in each leg of the load are not in phase with the voltage but bear the same relation to each other as the voltages since the load is electrically symmetrical. With the above arrangement, it was possible to obtain an accurate picture of phase-voltage relations under varying load conditions.

A motor fairly typical of three-phase synchronous camera motors was operated through the converter from a 115-v single-phase source and adjusted for capacitance balance at no-load in the manner previously outlined. The accuracy of balance in each case was probably of the order of ±2 v; about what would be expected in normal use.

Figure 3 shows the phase-voltage relations without correction for load change. In Fig. 3A the primary of T2 is compared to the primary of T1 which latter is also the line input and does not change with load. The solid line shows T2 at 140 v displaced 89° from T1 when the motor ran no-load. When the load was increased to just under pull-out, the voltage dropped to 112 v across T2 and the phase relation to T1 became 75° as shown by the dotted line. In Fig. 3B of the same figure is shown the resultant conditions existing in each phase winding of the motor. At no-load as again shown by the solid lines, the voltages to the mid-point were between 131 and 134 v with phases 121, 121 and 118° apart. With 100-w load on the motor, phase 1 has

Fig. 5. Engineering model of the Converter.

dropped to 104 v and shifted to 107° from phase 1 and 131° from phase 3, phase 2 has dropped to 118 v while phase 3 has shifted 4° and increased voltage slightly. As a result, the motor was noisy and the maximum stable power obtainable was reduced from 160 w mechanical to 100 w or 62½% of normal. This was chiefly due to the changes in phase 1 with some contribution from the reduced voltage in phase 2; the voltage change and phase shift of phase 3 being of little importance. In this connection it was found that unbalance of 10 v between phases, or 5 to 6° departure from the ideal, did not create noticeable noise or power reduction unless these factors combined.

Figure 4 is similar to Fig. 3 except that correction for increased load was made, as described, by means of the Variac T3. In Fig. 4A the phase shift and voltage change in the primary of T2 is small, being 2° and 4 volts, respectively. In Fig. 4B the phase shift in the motor windings is negligible (3° maximum) although some voltage unbalance exists due to an increase in voltage of phase

2 while phases 1 and 3 are reduced alike. This unbalance is not too serious and it appears only when capacitance balance has been made at no-load and load correction has been stretched to cover the whole power range of the motor. It should be noted in this connection that the motor load is 160 w under the conditions of Fig. 4 which is the same maximum power which this motor can deliver from a normal three-phase line.

Power Characteristics

Power output capacity sufficient to handle any motor or combination of motors would be desirable. Since this cannot be provided in a portable device, the maximum weight which can be carried by one hand (about 50 lb) was used as a base, and as much power as possible was provided within this limitation rather than selection of some arbitrary value of power. The result of this approach is a power output of about 400 va; the real watts and available mechanical power being determined by the power factor and efficiency of the motor. The engineering model is shown in Fig. 5.

The single-phase input power factor is relatively good and varies from 50 to 95%, while the conversion efficiency from single-phase to three-phase varies from 30 to 75%; both factors depending on the characteristics of the motor load.

In terms of equipment which can be operated by the converter, the following motors or combinations of motors appear to be within the power handling range of the unit:

Standard camera, synchronous motor — limited only by motor power
Standard camera and portable recorder, synchronous motors — above 50 F ambient
Standard camera and portable recorder, multiduty motors — any weather
Technicolor camera — above 50 F ambient

As previously noted the load demand of most cameras varies widely with ambient temperature and the weather is thus noted as a limiting load factor in some cases. Multiduty motors* operated in the synchronous mode function at relatively high efficiency and good power factor and thus heavier loads and/or more motors are operable from the converter than is the case with the usual variable reluctance synchronous type. It should be noted that the inclusion of this converter in a multiduty equipped channel adds single-phase, 115-v supply to the existing battery and three-phase power sources from which such channels can operate.

Conclusion

The development of a portable, nonrotary converter to supply three-phase, 230-v from a single-phase, 115-v source has seemed desirable in order to realize the inherent advantages of three-phase motors, particularly on motion picture cameras, while utilizing the convenience and availability of single-phase source of supply. Good phase-voltage balance is essential in such a device under variable load conditions, and it has been possible to obtain this by providing a simple form of indication together with a ready means of correction.

Discussion

William P. Kruse: Approximately what is the primary voltage on your resonant transformer during some various normal loads?

(*Communicated by*) *A. L. Holcomb:* The primary voltage of T2 is maintained essentially constant at 135 volts by adjustment of the Variac, as described, to meet the various load conditions.

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* A. L. Holcomb, "Motor systems for motion picture production," *Jour. SMPE*, *42:* 9–33, Jan. 1944.

Continuous Arc Projector Light Meter

By HARRY P. BRUEGGEMANN

This is a system for monitoring the light output of an arc projector during projection. It comprises a piece of optically flat glass, not silvered, placed in the projector light path, at an angle of 45°, and ahead of the film gate. The light thus thrown off to the side is measured by a photovoltaic light meter.

Arc projectors are normally built for theater projection, and they are designed to give a picture of pleasing quality. However, when arc projectors are used as laboratory production equipment for timing prints or for side-by-side comparison of prints, they must meet certain rigid specifications. One of these is the maintenance of an absolutely steady light output.

Experience at Cinecolor has been that arc projectors vary in their light output by as much as 20% during a 10-min projection, in spite of good operational practices and frequent equipment maintenance. This variation, of which the projectionist has no indication, seems to be due to the carbon feed, slight imperfections in the carbons themselves, voltage fluctuations and mechanical variables. A 20% change in light output would probably never be noticed in a theater, provided it is gradual enough. To a timer though, who is attempting to adjust scene densities to within one-half of a printer point of what the producer wants, a change of this magnitude is too great.

A number of systems for controlling the arcs were investigated. One such system consisted of a photoelectric cell, the output of which would control a thyratron, which in turn would control the carbon-feed motor in such a manner as to maintain a constant luminosity. This has the advantage of being automatic, the control being maintained without requiring an adjustment by the projectionist. As far as could be determined, there was no such thyratron arc controller on the market, hence it would have to be designed. Since Cinecolor already had some experience in designing thyratron controlled light sources, it was realized that this undertaking would be very expensive. All types of photoelectric light meters were eliminated, also, because of design expense.

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by George W. Colburn for the author, Harry P. Brueggemann, Cinecolor Corp., 2800 W. Olive Ave., Burbank, Calif.

The only system which seemed feasible would make use of a photovoltaic cell type of meter so arranged as to keep the projectionist continually informed as to the light output of the projectors. With this guide, he could maintain the light at the standard value by trimming the arc. A photovoltaic cell is practical because it maintains its calibration quite well if protected from heat, moisture and intense light. Since a great deal is known about the use of photovoltaic cells as light meters, design of such a system should be relatively simple.

Accordingly, a projector light meter was built around a photovoltaic cell. In order to monitor the light actually reaching the screen, a piece of unsilvered, optically flat glass was placed in the light path at an angle of 45°. This threw a beam of light off to the side of the projector, amounting to approximately 10% of the total output. This was more than enough for any photovoltaic cell, and at the same time caused a loss of only 10% in the screen brightness. This could be compensated for by trimming the arc. Obviously, the glass had to be positioned between the arc and the film gate.

The photocell was a Weston Photronic cell type RR, and the associated ammeter was a 0 to 20-μa, 2500-ohm Weston meter. Since the light from the optical flat was far too much for the cell, a means of attenuating this light was necessary. A dense green glass was placed ahead of the cell in the first model. This cut down the light to a workable level, but permitted a great deal of infrared radiation to be transmitted. This infrared energy raised the temperature of the cell too high for stability, so an Aklo heat glass was added. This promptly cracked. Thus it was evident that another means of reducing the heat was necessary. Ventilation slots were cut into the casting holding the cell, and this helped some, but the Aklo glass still would not stand up.

At this point the projectionists at the M-G-M laboratory, who had been informed of our project and had built a model of their own, thought of replacing the dense glass filter by a sheet of brass shim stock with pinholes. This solved the excess heat problem, since the infrared radiation was reduced as much as the light. The first Cinecolor model used a bakelite mounted photocell, but M-G-M used a metal-encased cell for conduction cooling. The M-G-M modifications resulted in a cell mounting which was only slightly warm to the touch, even after many hours of continuous operation.

The Weston microammeter, with its 2500-ohm resistance, gave a fairly linear response when coupled to the type RR Photronic cell. Various devices were considered for improving the linearity, including shunt resistances, lower resistance ammeters, and other types of photocells; but they all required more light, and consequently would have placed more heat at the photocell. Since heat dissipation was the biggest problem of the project, it was decided to accept the slight nonlinearity. The only advantage to improving the linearity would be to eliminate the scale compression in the operating range and thus increase the sensitivity. With the present model of the meter, however, luminosity fluctuations can be kept within about 3% and this is considered good. Most of this fluctuation is due to the coarseness of the trim, not the accuracy of the meter.

The location of the unit in the projector is shown in Fig. 1. This view shows the first Cinecolor model mounted in a Simplex projector, just above the framing knob. The rear end of the photocell, showing the bakelite casing, is seen together with the two wires leading to the microammeter. The ammeter is mounted on the wall of the projection booth just below the viewing

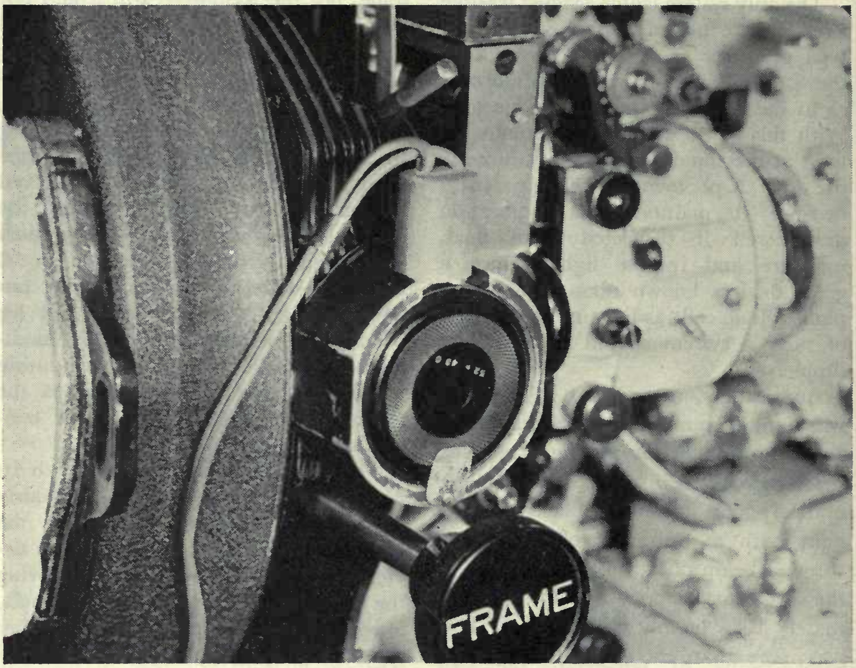

Fig. 1. View of the first Cinecolor model mounted in a Simplex projector.

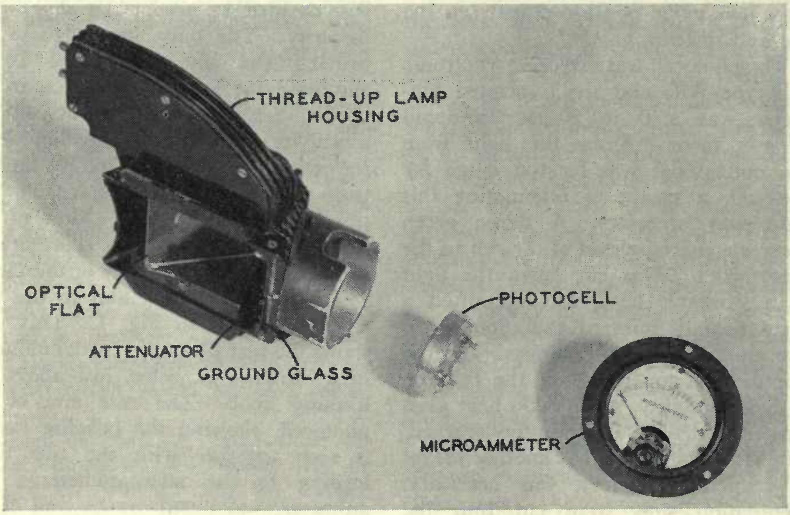

Fig. 2. The three basic units of the second Cinecolor model.

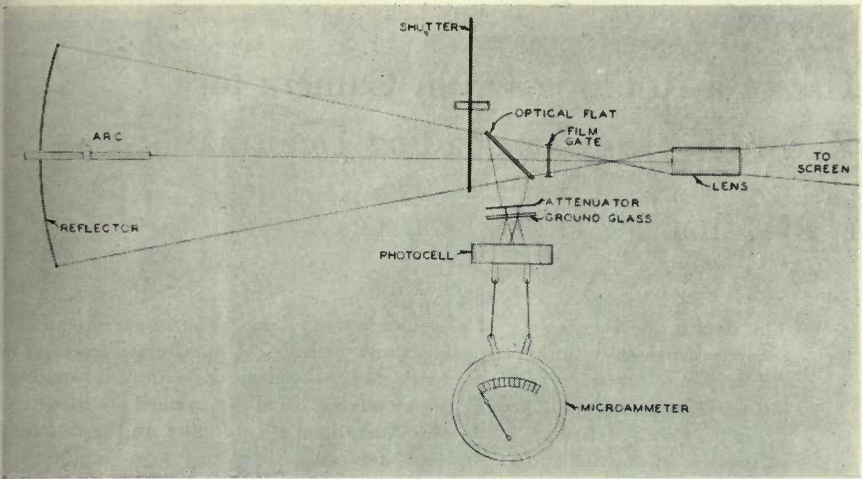

Fig. 3. Schematic of system — top view.

port, so that the projectionist can see the screen and the meter at the same time. Figure 2 shows the three basic units of the second model — the optical flat and brass attenuator mounting, the metal-encased photocell, and the microammeter. The optical flat occupies the space normally used by the thread-up lamp when it is lowered for threading up. The lamp was repositioned so that it missed the optical flat when lowered. The perforated brass attenuator slides into a slot cut just ahead of the photocell housing. The edge of the attenuator is visible in the figure. There is a ground glass immediately behind the attenuator to break up the light through the pin holes, and thereby avoid any local "hot spots" on the surface of the photocell. Figure 3 is a schematic drawing of an arc projector with the unit installed.

In operation, the system requires only a 5-min warm-up period in the morning, after which it will remain constant all day. The warm-up is necessary because the photocell has greater sensitivity when cold, and temperature equilibrium must be reached before the system stabilizes. During projection, the operator needs only to keep the needle at a constant standard value by appropriately trimming the arc. The use of this system has resulted in a great improvement in projection quality, both at Cinecolor and M-G-M.

Thanks are expressed by the author to James Phillips, Chief Projectionist at Cinecolor, for initiating and doing most of the original work in this project, and at M-G-M to Merle Chamberlain, Chief Projectionist, and Clayton C. Troxel, Jr., Projection Engineer, for their modification which contributed to the success of the final model.

Use of a Rotating-Drum Camera for Recording Impact Loading Deformations

By D. F. MUSTER and E. G. VOLTERRA

The details of a rotating-drum camera are described. The camera is used to record displacement-time data for short cylindrical specimens made of a rubberlike material which are subjected to compressive impact loadings lasting from 5 to 20 milliseconds. The auxiliaries to the camera are discussed in light of the particular needs of a study being conducted on the dynamic properties of plastics and rubberlike materials.

An investigation on the dynamic stress-strain properties of plastics and rubberlike materials is being conducted at Illinois Institute of Technology under the sponsorship of the Mechanics Branch, Office of Naval Research, as part of their basic research program on the properties of materials.

For determining directly the stress-strain curves of plastics and rubberlike materials subjected to impact loads, the duration of which are of the order of milliseconds, a special apparatus has been built which uses mechanical and optical devices. The paper is confined to only a brief description of the optical parts of the apparatus, and particularly of a special rotating-drum camera and its accessories which is used to record displacement-time data for the specimens being tested.

The apparatus employed in the experiments is shown in Figs. 1, 2 and 3. It consists essentially of:

(1) two 3-ft, 1-in. diameter steel bars, of equal mass, suspended as ballistic pendulums;

(2) a rotating-drum camera, the drum of which rotates at a known speed, and the shutter of which is synchronized to operate with the motion of the steel bars;

(3) an optical system which focuses the image of a very thin slit on the knife edges machined on the adjoining ends of the steel bars; and

(4) an electromagnetic device which can release one or both of the bars at the same time.

The cylindrical specimens of plastics or rubberlike materials to be tested are $\frac{1}{2}$ in. in diameter and $\frac{1}{2}$ in. long. They are placed on the plane end of one of the steel bars such that the longitudinal axes of the bar and of the specimen coincide. The other steel bar is released from a predetermined height by a magnetic release mechanism and is made to impinge upon the free end of the specimen. During the impact a photograph is taken of the interval between the knife edges which lie in the plane of the ends of the steel bars.

Presented on April 23, 1952, at the Society's Convention at Chicago, Ill., by D. F. Muster and E. G. Volterra, Dept. of Mechanics, Illinois Institute of Technology, Chicago 16, Ill.

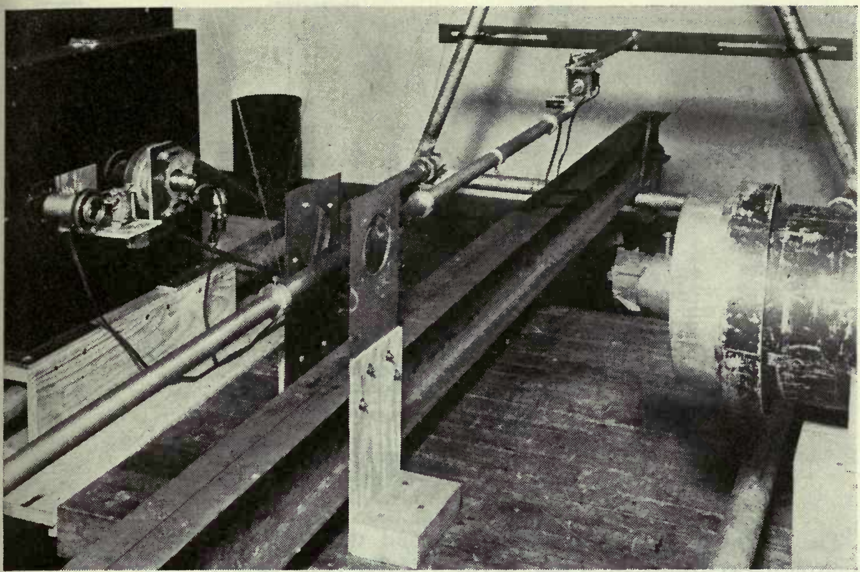

Fig. 1. Front view of camera.

Fig. 2. Back view of camera.

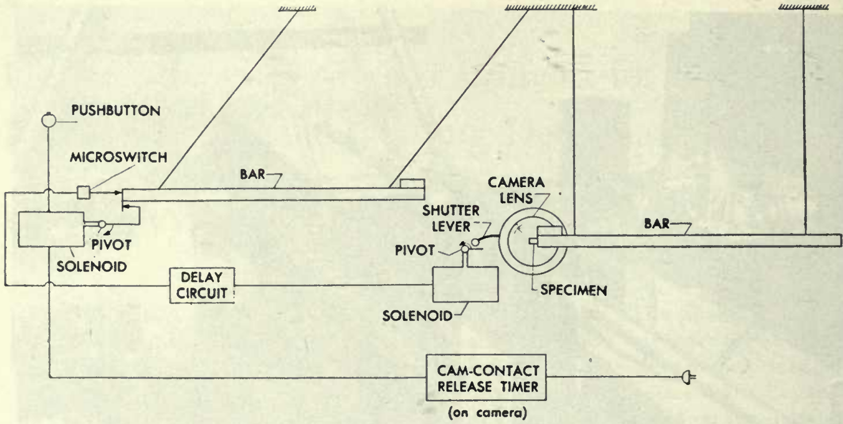

Fig. 3. Schematic diagram of equipment arrangement.

The magnetic release mechanism is controlled electrically by a cam device (shown on the camera shaft in Fig. 1), which serves to time the release of the bar with the position of the film on the drum. This insures that the exposed strip of film will not include the overlap region where the two ends of the film are joined.

A delay circuit is adjusted so as to cause the shutter mechanism to operate during the time interval of from 5 to 20 msec during which the impact between bar and specimen occurs. The record on the film strip is calibrated by superposing a still photograph of the distance between the two knife edges when both bars are just in contact with the specimen.

The data on the film strip are read by direct measurements made with a microscope mounted on a movable base. The base is fitted with two orthogonal motions and can transverse a maximum of 4.5 in. in increments of 0.001 in. From these data the displacement-time relationship is plotted.

The camera body is made of $\frac{1}{4}$-in. thick aluminum alloy plates. Front and back views of it are shown in Figs. 1 and 2. All joints have been sealed and the entire assembly painted dull black. The back of the camera body is mounted on hinges which permit easy access to the drum. The back is locked in position by four trunk-type fasteners and is light sealed by a $\frac{1}{16}$-in. thick neoprene gasket cemented to its inside surface.

The drum was turned from a 2-in. cold-rolled steel plate and its finished dimensions are indicated in Fig. 4. It is mounted in the camera on a keyed shaft with a large hex nut to facilitate easy removal in the dark. The film is placed on the inner surface of the drum and held in position by two spring-metal strips which grip the film strip at its edges. The drum accommodates a 48-in. length of film, which permits a slight overlap, and there is a useful length of approximately 40 in. of film.

In the drum periphery there are two $\frac{3}{8}$-in. radial holes that are used to focus the slit image on the film strip. There is a corresponding hole fitted with a sealing flap in one end of the camera body.

The drum is driven by a small induction motor rated at $\frac{1}{40}$ hp at 900 rpm. Through a belt and pulley arrangement, the speed of the camera drum is reduced

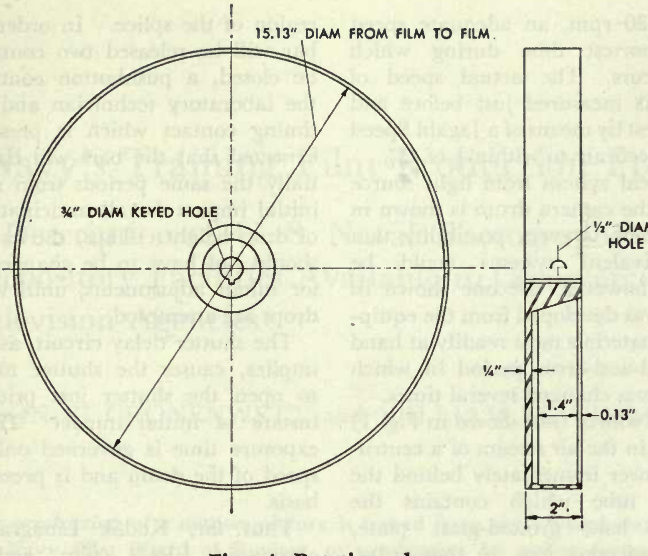

Fig. 4. Rotating drum.

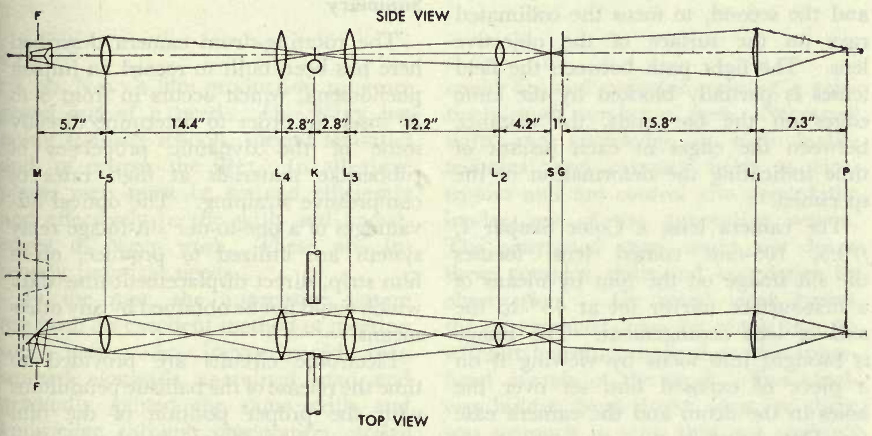

Fig. 5. Schematic diagram of optical system.

P....Projection Lamp, GE 750T12P
G...Ground-Glass Plate, 2 in. × 3 in.
S....Slit, 0.001 in. × $\frac{7}{8}$ in.
K...Knife Edges on bars
M...Mirror, first-surface set at 45° to axis of lens arrangement
F....Film, Kodak Linagraph Panchromatic LP421

L_1...Condensing Lens, 6in. $f/1$, $4\frac{7}{16}$in. diam
L_2...Projection Lens, 75mm $f/1$, 49mm diam coated achromat
L_3...Plano Convex Field Lens, 17 in. $f/1$, $3\frac{1}{2}$ in. diam
L_4...Plano Convex Field Lens, 21 in. $f/1$, $3\frac{1}{2}$ in. diam
L_5...Camera Lens, Color Skopar $f/3.5$, 105 mm $f/1$

to about 120 rpm, an adequate speed for the shortest time during which impact occurs. The actual speed of the drum is measured just before and after each test by means of a Jagabi Speed Indicator accurate to within $\frac{1}{2}$ of 1%.

The optical system from light source to film on the camera drum is shown in Fig. 5. There is every possibility that other equivalent systems could be designed; however, the one shown in the figure was developed from the equipment and materials most readily at hand after a trial-and-error period in which the design was changed several times.

The light source (not shown in Fig. 1) is mounted in the air stream of a centrifugal air blower immediately behind the cylindrical tube which contains the condensing lens, ground-glass plate, slit, and projection lens, in that order. The impact phenomenon occurs between a pair of field lenses, the first of which serves to collimate the light rays and the second, to focus the collimated rays on the surface of the objective lens. The light path between the field lenses is partially blocked by the knife edges on the bar ends, the distance between the edges at each instant of time indicating the deformation in the specimen.

The camera lens, a Color Skopar I, *f*/3.5, 105-mm coated lens, focuses the slit image on the film by means of a first-surface mirror set at 45° to the axis of lens arrangement. The image is brought into focus by viewing it on a piece of exposed film set over the holes in the drum and the camera case (see Figs. 1 and 2).

There are two electronic circuits which are important to the proper operation of the camera:

(1) the timing circuit of the bar release mechanism; and

(2) the shutter delay circuit.

The former operates through a cam on the shaft of the camera and times the release of the impinging bar so that the exposed strip of film will not include the region of the splice. In order that the bar will be released two contacts must be closed, a pushbutton controlled by the laboratory technician and the cam timing contact which is preset. It is expected that the bars will have essentially the same periods from release to initial impact for all anticipated values of drop height. Thus, the cam setting should not have to be changed, except for minor adjustments, until very large drops are attempted.

The shutter delay circuit, as its name implies, causes the shutter mechanism to open the shutter just prior to the instant of initial impact. The actual exposure time is governed only by the speed of the drum and is preset on this basis.

Thus far, Kodak Linagraph Panchromatic LP421 film and Dektol (D-76) developer have been used with good results.

Summary

The rotating-drum camera described here has been built to record an impact phenomena, which occurs in from 5 to 20 msec, in order to determine directly some of the dynamic properties of rubberlike materials at high rates of compressive straining. The optical advantages of a one-to-one slit-image relay system are utilized to produce, on a film strip, direct displacement-time data which could not be obtained by any other means.

Electronic circuits are provided to time the release of the ballistic pendulums with the proper position of the film in the camera and to delay the opening of the shutter until just before the instant of initial impact.

Acknowledgment

The authors wish to thank R. E. Lewis, Physicist, Armour Research Foundation, and R. A. Einweck and C. R. Olson, Illinois Institute of Technology, for their help on this and other phases of the project.

The Navy's Training Film Production Program

And a Description of U. S. Naval Photographic Center Film Depository Facilities Available to Commercial Film and Television Agencies

By WILSON R. CRONENWETT and WILLIAM M. TIMMONS

The production of a motion picture is traced from the request stage through the Navy Film Board of Review, to production by either commercial contractor or the Navy Photographic Center. Film distribution is described, and also the special photographic services available to the film and television industries by the Naval Photographic Center's film depository.

THE NAVY'S film production program grows out of a need. The Navy has many training schools, special activities and, of course, the fleet. In all these places men must be trained efficiently and effectively in the skills and knowledges of Navy work. These are intensely practical needs.

In the past, the apprentice system has been an excellent method of meeting such needs. An inexperienced man worked alongside a trained man and gradually gained the same skills and knowledge through observation, active learning and correction of mistakes pointed out by the trained man. The apprentice system, however, was slow, could be used only for training a relatively small number of men. Necessary skills and knowledge in such highly technical and complex fields as electronics and fire control also proved the inadequacy of the apprentice system. The untrained man could not learn these complex skills and knowledge by observation. He could work beside the experienced man for many months without learning more than the superficial aspects of the work. Too much was hidden from direct view, or there was so much to view that one couldn't interpret it.

The training film, along with other aids and methods, has solved the training problem. It has many of the merits of the apprentice system, while at the same time permitting observation of those things which are normally hidden or which are cluttered up in a maze of detail. It is equally useful for teaching simple skills and techniques, and highly

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by LCDR Wilson R. Cronenwett, USN, Head, Motion Picture Branch, U.S. Naval Photographic Center, Anacostia, D.C., and Dr. William M. Timmons, Educational Adviser, Naval Photographic Center.

complex and technical ones. Moreover, it can effectively and rapidly teach many men simultaneously.

This was the need that had to be met during World War II. It was a big need and was not met all at once. The program grew. In the summer of 1941 the staff to meet the need consisted of one junior officer. By 1945 over one hundred officers were supervising the production of films. The Photo Science Laboratory had its own staff of writers, cameramen, editors, and technicians. There were about 30 training aids libraries and about 70 officers advising on film utilization. By early 1945 over 1000 motion pictures had been produced, as well as 2500 slide films. Close to a million prints had been distributed.

The films produced were good, bad, and indifferent. A surprising number were superior. All contributed to the practical job of training many officers and men in Navy skills and information. That they were generally good is due to a number of factors. The Navy leaned heavily on many small commercial producers who had developed considerable know-how in producing films for business and industry — practical films, often training films. The officers recruited as project supervisors came from two primary sources, the film industry and education. They, with the small commercial producers, made Navy films what they were.

The project supervisors with their diverse backgrounds were a source of ideas, methods and procedures, as well as of disagreements. They did not solve all the problems of how to make films that do the practical teaching job. But out of the ferment of the war-time group there came at least these results:

(1) A set of production procedures were worked out. (These are still used.)

(2) Production control procedures were developed. (These are still followed, with refinements.)

(3) Emphasis was placed on a new type of film, one designed to teach rather than to entertain.

We knew what we wanted but we did not know all the techniques of making films that teach. We still do not know, but we have made progress.

On the basis of this background, I want to indicate how the Navy's film needs are met today — what the program is today. There are three basic aspects to the program: production, distribution and procurement.

Production

The overall responsibility for film production in the Navy is in the hands of the Bureau of Aeronautics, Photographic Division. Production supervision and control are delegated to the U.S. Naval Photographic Center. All training films are therefore produced in their entirety at NPC or are produced commercially, under the Center's supervision. In either case they are produced in close coordination with that part of the Navy desiring the film.

Although we have the usual administrative personnel to keep the entire program moving and an educational specialist to insure that each film does its intended teaching job, the key people on any production are two in number. One is the project supervisor, representing the Naval Photographic Center. The other is the technical adviser representing the Naval activity, school, Bureau or fleet unit wanting the film.

The project supervisor acts as the producer of his assigned projects. He may be responsible for as many as twenty projects at one time. He is responsible for planning, scheduling and supervising all except purely technical aspects of his projects from initial request to final acceptance of the training film. He must make sure that each of his films does the intended teaching job, is right as a motion picture, and is made within the allotted budget. He must judge the work of script writer, graphics

specialist, camera man, director, editor, animators, sound technicians and processing technicians. Naturally he leans on others to the extent needed, but his is the final responsibility.

The technical adviser is an expert in the content of the film. His basic responsibility is to make sure that the script and the resulting film are technically accurate and technically complete in all details. In addition, he must make sure that incidental things shown are right, that approved safety procedures are followed, that all clothing is properly worn, that security regulations are followed in what is shown, and that even little things like haircuts are strictly Navy.

The training film which these two individuals, project supervisor and technical adviser, work on may be any one of several types: motion picture, photographic report, public information film, slide film or filmagraph. While this classification may sound illogical, the terms have grown in response to the Navy situation. Some of the terms are self-explanatory. Others need a word of explanation. A motion picture is any carefully planned, complete motion picture production, in live action or animation, designed for training purposes. A film on *How to Get Usable Motion Picture Footage* falls into this category. A photographic report consists of motion picture coverage of an actual operation or activity put together in the best way possible to give general professional information to Naval personnel. A film showing an actual amphibious landing, covered photographically as well as circumstances permit, is a photographic report. A public information film is any motion picture telling the public about any part of the Navy. The slide film needs no definition. The filmagraph is essentially the same as a slide film except that the still pictures and the sound are put on motion picture stock, and the resulting film is projected on a standard sound motion picture projector. With careful planning, standard opticals and the use of popped-on or dissolved-on items or labels, camera trucks and simple pans, the filmagraph becomes a simulated motion picture. For certain kinds of content, where continuous motion is unimportant or where motion can be simulated by simple techniques, the filmagraph is an excellent, low-cost teaching film. We have used the filmagraph, for example, to show how to bend oak timbers and to explain the Navy's part in our Revolutionary War. In the Navy the filmagraph has largely replaced the slide film.

During the fiscal year now ending, of the films going into production 72% were motion pictures for specific training purposes, 10% were photographic reports for general training purposes, less than 2% were public information films, 16% were filmagraphs for specific training purposes, and none were slide films.

Thus, Navy production consists primarily of films for training. These films follow a general pattern of production. At the outset someone in the Navy has a training problem which he thinks can be solved by a film. In consultation with a representative of his parent Navy Bureau and an educational specialist from the Naval Photographic Center a decision is made that a film will or will not help solve the training problem. If it is agreed that a training film is desirable, they prepare a production outline. The production outline is a detailed analysis of who will see the film, what the audience already knows, what they should know or be able to do after seeing the film, the content to be included, the technical photographic specifications and shooting locations. In other words, the production outline includes the basic specifications on which the script and film will be based. Every effort is made at this stage to insure that only needed films are requested

and that the requested film will be a good teaching film.

The production outline is submitted to the Navy Film Production Board of Review. This board is made up of officers representing the training and fiscal parts of the Navy. They determine what training films are to be produced, the priority and the basic specifications for each film. For a film to be approved, the need must be justified, the plan must appear educationally sound and the project must represent a wise expenditure of public funds.

If the Navy Film Production Board of Review approves the project, the Bureau of Aeronautics assigns it to the Motion Picture Branch of the Naval Photographic Center for production. It becomes either an NPC production done entirely with NPC facilities or an NPC contract production done with the assistance of a commercial studio. Productions done entirely at the Center are normally those of the highest security classifications or those requiring shooting on location or intermittent photography that cannot be done efficiently by commercial studios.

Regardless of how the film is to be produced, the Photographic Center assigns the project to one of its twenty project supervisors. The requesting part of the Navy assigns a technical adviser. These two individuals supervise the preparation of a script. In all cases where art or animation is to be included in the film, the script includes a detailed storyboard. The resulting script must be more than technically correct. It must be capable of being produced at a reasonable expenditure of time and money. Expensive color is used only if it will contribute to the teaching quality of the film. The comparatively inexpensive filmagraph is used rather than the motion picture if the former will accomplish the film purpose as effectively. If a short film will do the job, no padding out is permitted. The script must be consistent with the specifications laid down by the Navy Film Production Board of Review, in accord with governmental policy and in good taste in all respects. It must lend itself to becoming a good film from the point of view of direction, photography, editing and sound. Above all it must be educationally valid.

It is on the educational side that we are making perhaps our most outstanding contribution. Emphasis on educational effectiveness is placed at the script stage. If the script is educationally sound and if the production follows the script, there will be little difficulty in making the resulting film educationally sound.

We shall not discuss our educational standards in detail here, but it may be helpful to indicate a few of the general principles followed. The script should make the learner aware of what is expected of him. The script should be carefully organized around the chief instructional values to be gained from the film, and this organization should be prominent in the presentation. The detailed development of every part of the film should be slow and clear in pictures and words, with primary emphasis on informative picturization. The treatment should be consistent with the film purpose and should generally be expository rather than telling a story or hanging on "gimmicks." The commentary should be simple, precise, brief, direct, dignified and closely integrated with the pictures. The introduction should be no longer than necessary to take the learners from where they are in information to the body of the film. The conclusion should reinforce the chief learnings. Obviously, the project supervisor must lean heavily on education and cost experts to make sure that he is meeting all his responsibilities at the script stage. In the same way the technical adviser must lean on other experts on fine points of the film content.

The script and storyboard must be approved by the superiors of both the project supervisor and the technical adviser.

Then the project goes into production, following the normal procedures of the industry. Because emphasis in directing, photographing, processing, editing and recording is on accomplishing the film purpose with integrity and authenticity, departures from the approved master script are never made for reasons of caprice, entertainment or aesthetics but only when changes are mandatory from a teaching point of view. The standards set by the industry on the technical aspects of photography, processing, sound and other film matters are followed by the Navy and the superiors of the project supervisor carefully check these aspects at interlock and acceptance screenings.

Distribution

The training aid to meet a specific training need has become a reality. To move this physical film to the many training schools, naval activities, reserve schools and the fleet, is a prime responsibility of Naval Film Distribution. Since the Navy is responsible for the production of all motion pictures for the Marine Corps, provision is also made for distribution to that part of the Naval Establishment. Operating under the Training Division of the Bureau of Naval Personnel, this activity has long been aware of the production progress of the motion picture. Following the Acceptance Screening of the picture at NPC, the film is screened before specialists at the Bureau of Personnel. These personnel have had pre-production information concerning the specific need for this particular training aid and have had conferences with the sponsoring Navy Bureau. The total number of film copies needed to perform the best training job is ascertained. Copies of such a highly specialized film as *African Trypanosomiasis* will not compare with the need for copies of a film on *Small Boat Disaster Prevention.* Normally, each major training film library will have at least one copy of every film made, and in the majority of instances, they will have numerous copies available to service the many users. With the recall of many reservists and the demothballing of ships, the major training film libraries will have many of the hundreds of copies made so that fleet units will be able to carry on immediate training with these aids. Within a month following the Korean outbreak, fleet demands swept the shelves of all extra copies of training films. Since the Navy film program was instituted, over 1,300,000 prints of training films have been distributed. The training potential of these prints is undeniable. To answer the question in your minds as to actual printing procedures, the work is divided between the printing facilities at NPC and commercial firms awarded printing contracts through competitive bidding.

The Navy feels that its distribution program must differ from present-day commercial practices. Since a 16mm print is relatively inexpensive, the emphasis is on making sufficient prints of a picture to insure that its information can be quickly disseminated, be readily available, and in such quantities that it will therefore satisfy the original need for the training medium. It is not unusual for print requirements to exceed 300 copies before a script is written or a camera grinds.

Procurement

This last of the three points deals with procurement practices of scripts and motion pictures not produced directly on the NPC sound stage, or by NPC crews.

Last year, over 100 motion pictures were completed for the Navy and the Marine Corps. Of these, 25% were service-produced at or by NPC. The remaining 75% were produced com-

mercially under our direct supervision, as shown above.

Almost daily, independent producers, large and small, self-styled professional cameramen, and small photographic facilities want to know whether they can make Navy pictures, whether they are large enough to produce for the Navy, what equipment they must buy to produce for the Navy, if the Navy will underwrite an initial production, and they ask a thousand other questions that might be considered laughable, were it not for the seriousness of their intent.

Navy motion pictures have been produced commercially by Hollywood's biggest firms, and by smaller producers in Chicago, Philadelphia, Atlanta, Detroit, Pittsburgh, New York, St. Paul and elsewhere.

There are six steps that must be taken by a producer wishing to make films for the Navy.

(1) In a letter in triplicate, addressed to the Chief, Bureau of Aeronautics (PH), Department of the Navy, Washington 25, D.C., give a résumé of your organization, including type and brief history, and state whether you are a corporation, a partnership, or sole proprietor.

(2) State that you are interested in Navy film production and the type you consider yourself best suited to handle. This information gives the procurement officer a better understanding of your capabilities and the kind of work on which to give you an opportunity to bid. If you are one of hundreds on a list, it isn't very practicable to ask you to bid on a film which will employ highly specialized types of medical photography, or other techniques in which you are not experienced. If the film is to be 100% animation, do you have an animation stand? Neither is it practicable, if you are located on the West Coast, to ask you to bid on a submarine film to be shot in New London, Conn.

(3) List your key personnel and give a brief outline of their experience in motion picture work.

(4) State the major types of facilities and equipment owned, or how made available to your company. There are no arbitrary rules about the size of your studio, nor will the Navy look askance at having sound recording done in a studio established for that purpose. However, if the major portion of your equipment is not owned, you are in effect not in the motion picture business.

(5) Enclose a balance sheet listing your assets and liabilities. The information will be held in strict confidence. Give the straight facts. The Navy's procurement analysts aren't to be fooled. The Navy does not pay in advance and the Government cannot sponsor you in business. The concern is whether you have the capabilities to complete an awarded contract. The emphasis is upon financial "soundness."

(6) Forward samples of pictures recently produced by your company, preferably educational or training films. The Navy wants to know what you can produce *now*, not what you produced several years ago.

The emphasis is on these basic factors: (1) experience (*and the kind of experience*); (2) key personnel and *their* experience; (3) physical facilities in terms of equipment owned; (4) financial stability; (5) the films you have produced and for whom; and (6) security clearance.

There are no geographical advantages, except that certain kinds of physical work naturally gravitate to the most convenient qualified source. But it is equally important to note, as all producers would emphatically agree, that national assignments involving considerable distances and location work have no such boundaries, that Eastern, Midwestern or Western companies work over a considerable geographical area.

The Navy takes considerable pride in its past and present procurement practices with commercial producers,

large and small. This association has been singularly marked by a fine spirit of mutual cooperation.

Conclusion

This has been a general view of the Navy's training film production program. It is a big program: 6091 films have been produced since the program was started back in 1941. It is an important program: the films have helped train thousands of officers and men. It has made at least a small imprint on civilian education and training: over 600 titles have been released to the public through the Office of Education, some of them selling as many as 1000 prints. The program owes much to the reserve officers who got it under way. It also owes much to the film industry. We are constantly trying to make it better — not for the sake of being better, but so that through training films more men can be trained better and faster to do jobs that have to be done.

Supplement

The Naval Photographic Center's film depository and its service to the film and television industry are apparent to everyone who is familiar with the Navy's cooperation and assistance in the production of such feature pictures as *Frogmen*, *Submarine Command*, *You're in the Navy Now*, the television documentary serials *Crusade in Europe* and *Crusade in the Pacific*, and in other current television shows and weekly newsreels. The film depository at NPC contains over 30 million feet of historical stock footage shot by Navy and Marine cameramen. In many instances there is duplicate material from other services. Non-classified sections of this storehouse of film and certain other services are available to commercial producers. The Navy, with the other services, has extended military cooperation or has collaborated on the production of commercial motion pictures for both theatrical and television release. Included under cooperation is the search for, and use of, official stock motion picture footage in connection with commercial pictures.

The clearinghouse for all requests for cooperation from any of the services, including the use of Navy-owned stock footage, is the Commercial Cooperation Unit, Pictorial Branch, Office of Public Information, Department of Defense. The wait for such help is not as long as the address mentioned, for the government understands that motion pictures, whether full-length features, documentaries or short subjects, and whether intended for theatrical or television release, are a vitally important and far-reaching means of sustaining public understanding of the military. The Commercial Cooperation Unit is geared to get applicants the help they need, and coordinates it through the Office of the Chief of Information — Department of Navy, which handles all further details. At this point, NPC enters the picture. The time lapse is surprisingly short. For instance, a request was made and filled within 48 hours for eight minutes of stock footage to accompany the TV appearance of CDR Gray, USN, on the program "We the People." The Naval Photographic Center film depository will arrange a convenient time for you or your representative to screen selected stock footage, or if the requirement is small will choose the material you need and forward it to you.

It is understandable that the amount of cooperation for stock footage or other services is directly proportional to the reach or scope of the production and its potential informational value. Requests for small lots of stock footage are filled as a public service. Either a fine-grain or a Kodachrome printing master is supplied. In the instances oi stock footage for Hollywood major productions, arrangements are made to reimburse the Navy with a like amount of raw stock.

It would be well to mention here that an average of 80,000 ft of motion picture negative was coming to NPC from Navy sources all over the world each month before the outbreak of the Korean war. Since then, the shipments of original unprocessed negative stock has risen to 200,000 ft a month. In every case where security permits, a fine grain of selected footage of timely public interest is sent by the Department of Defense to the newsreel and television pool in New York. Duplicate negatives of this timely footage are then purchased by production organizations from a commercial printing laboratory in that area.

Your initial request for cooperation will bring a full set of instructions from the Department of Defense. The necessary, but small details, will not be given here. The most important facet of this situation is this consideration: if Navy footage is required, your production will be impracticable or impossible without official cooperation from the Navy. You will need to furnish a statement of your intent to produce and distribute for public consumption, a feature or short subject motion picture or television show based on some phase of the Navy. Your script will be included, and pertinent information as to the type of assistance required, i.e., stock footage, sound effects, technical advice, clearance to board Naval vessels or aircraft, or to borrow military equipment needed for authentic scenes, or actions.

In any event, security must not be compromised, the cooperation must not interfere with private enterprise, it must not interfere with military operations or the command concerned, and it must not cost the taxpayer or the government anything. An excellent illustration of such cooperation was the recent request by a major Hollywood studio wishing to photograph aviation activities aboard a carrier. No such ship was immediately available for use on the West Coast but the camera crews were able to board a flattop on its way to Korea and do their necessary photography before the ship reached Hawaii, at which point the commercial crews departed.

Discussion

M. R. Klein (Director of Army Film Library Services): Does the Navy instructor use a teaching technique in using the training film prior to showing the film? And also as a follow-up after the film is shown? In other words, are pertinent questions about the film prepared as part of the teaching technique in using your film?

W. R. Cronenwett: If I might comment as a former enlisted man, I saw a great many training films before I got into my present work. The Bureau of Personnel Training Division strives in every way to prepare a "package," so that the film or other visual aid is not the sole teaching medium, but exists as one of the teaching tools with which the Navy instructor works. We have made films for the trained and untrained instructor, who then knows — before he ever meets an audience — what he should do, how to bone up, the questions to ask, what questions he might be asked, and the answers. The film, the instructor's booklet, the other visual aids, the instructor — the human element — meld to train the fleet as best we can. I hope I've answered your question.

Howard Johnson (Federal Civil Defense Administration): Referring back to the production aspect of your paper, I think there are three points that require re-emphasis — three significant contributions of the Navy training film program. A good many of us will agree, I think, that the storyboard concept of planning a film is important in the documentary training film area; secondly, that most training films are one reel in length, which is important for curriculum integration, important for proper film utilization aboard ship or the shore station; and thirdly, that most Navy training films are documentary training films, in the best sense.

I would like to have you comment again on the emphasis of the storyboard planning for film production and its value.

LCDR Cronenwett: We find that in working with many people in the Navy

who do not have a film production concept that the use of a storyboard, with the script, will enable the requesting authority, and others who will pass upon the film before it gets to the fleet, to visualize the final product. As to film length, we feel that a film should be designed for a specific need. That is, if it needs to be a 3½-minute film, we'll make it; if a 13-minute film, we'll make that too. Too often a contract might call for a two-reel picture, and when 18½ minutes of film will do an adequate job, the film editor will needlessly lengthen the scenes to fill the two-reel requirement.

What was your third point, Mr. Johnson?

Mr. Johnson: Emphasis on the documentary . . . .

LCDR Cronenwett: Many of our films, as you can well imagine, are documentary in approach since many of them are photographic reports. In other words, we'll go out to cover an amphibious landing as best we can, without preplanning, because you can't always know what's going to happen. It would be as though we had planned to kine the show we saw on TV here this afternoon. Something invariably happens. May I say here, with pardonable pride in behalf of those people — officer and civilian — who have made training films for the Navy since 1942: twelve Navy films have won 16 national and international awards. I think these awards are based upon educationally sound, technically accurate, and technically well made motion pictures.

Nonsilver Photographic Processes

By THOMAS T. HILL

A number of nonsilver photographic, or light-sensitive systems such as those based on diazo dyes, have been used or proposed for specialized purposes. None of them, as yet, exhibits the sensitivity or the wide applicability of the silver process. This survey of the current status of these systems will discuss current limitations as well as possible future prospects with particular reference to the field of motion picture engineering.

Defined broadly, photography is a very widespread field. It includes all those systems by which an image can be made more or less permanent, an image resulting from an exposure to some type of light. Occasionally we see mention of new systems of photography and though they are often very promising, we are still working with the silver system of photography. So, the question arises, "Why haven't some of these other possibilities come into use?"

This paper will review some of these other possibilities, their advantages and their disadvantages in comparison with our current silver system, and discuss what we are likely to hear from them in the near future.

First, however, we must note that, while we grumble about the shortcomings of the silver emulsions which we now use, the necessity of processing them in solutions and finally the necessity of using them properly, they are really very versatile and set a high mark of accomplishment against which to compare the new possibilities. Examples of the wide versatility of silver-salt photography are easy to find, ranging from astronomical photography to photomicrography.

A discussion such as this one develops a new respect for the silver system, in that it is applicable to so many aspects of our work. On examination, we find that many of these newer light-sensitive systems are of narrow ranges of usefulness.

Photographic chemistry is but a branch of photochemistry, which studies all reactions caused by or accelerated by exposure to light. Among the many photochemical reactions are some which appear to be bases of new photographic systems, but which on further study are either so insensitive or have so limited an application that they are not really practical.

Among the possible light-sensitive systems of interest to us at present are the following (some of these, of course, are physical as well as chemical systems):

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diazo dyestuffs; diazo sulfonates; metal-diazonium system; dye bleach color systems; gelatin dichromate systems (and similar ones used in the graphic arts); thermography (such as the Minnesota Mining system); light-sensitive glasses (such as those of Corning); differentially hardened plastics and resins (such as bitumen, etc.); miscellaneous metals and metal salts (including those of lead, thallium, selenium, etc.); iron (such as those in blueprints); electro-photography (such as Xerography); platinum and palladium compounds (actually used in making prints from silver-salt negatives); and mercury salts.

Some of these processes or systems appeal to us because of either simplified processing, adaptability to varied temperatures, low costs or great stability in the final product. But, when balanced against the advantages of the silver process, they have all, up to now, fallen short, except for single specialized uses.

It is that aspect which will be discussed here in some detail. We should know something of what we can expect from these "new" systems and what we should not expect from them. In some cases, enthusiasm has been substituted for results, and we have to use some caution in assessing the reported examples of new proposals.

Evaluation of various systems:

Of course, not all of these nonsilver systems are new; many of them have been used for years for specific purposes. One of the most used is that based on the light-sensitivity of iron compounds which form a blue-colored salt upon exposure to light. We are all familiar with the blueprint, and many of us have used blueprint paper to make prints from still-camera negatives. The process, as you will recall, is very slow, requiring strong artificial light, or sunlight, and in most cases the papers in use are designed for high contrast rather than for continuous tone reproduction. As generally used, the results are not as permanent as silver images, although with proper treatment they can be made quite satisfactory.[1] But such special treatment eliminates two of the blueprint's advantages, low cost and simple processing. On these bases, together with the low sensitivity, we can eliminate this system from our consideration as a possible competitor to a silver compound in actual motion picture work.

In the field of plans and engineering drawings, the diazo print[2] is replacing the blueprint since it is a positive method, giving a positive copy of the original, and having greater contrast. Properly prepared, it is also more stable. Because of its ease and cheapness of processing and the low cost of the original material, the diazo system of photography is more promising than many others, and much effort has been put into it to make it more useful, and more of a competitor to the silver system. However, it has some important disadvantages from our present viewpoint, mainly very low sensitivity and a limited tone range. For black-and-white photography, the diazo system has another disadvantage in that there is no true dense opaque black available. The best blacks, so far, in this field are mixtures of dyes giving a very dark color which appears black on an opaque-base print, but does not have the density of a silver material.

The low sensitivity here is the problem which we meet again and again in studying the various nonsilver systems. In general, the advantage of the silver system is that it can be sensitized (in the meaning of that word used by emulsion chemists). That is, by adding small amounts of certain dyes and organic compounds together with sulfur compounds, the sensitivity of silver salts to light, including now the use of fluorescent materials, is greatly increased. But there is another great difference. In silver photography, a latent image produced by a very small amount of

light is sufficient to give us the final results. This is because the working image is formed from that insignificant latent image by chemical reactions which themselves put energy into the system. In the case of diazotype, this is not the case, and all the energy needed to form the image must come from light energy. This is, of course, limited by the quanta of light available. In the case of the diazo system, which is a positive process, the light destroys the ability of the colorless dye precursor to couple to form the colored dye. Thus the areas receiving the most light, of course, give the least color on development, and those receiving no light give the densest color. But the energy necessary to make the change which produces the image is a result of energy applied to the system by the light, which makes the exposure. The chemical reactions taking place in the coupling reaction after exposure do not introduce chemical energy in the way that a silver photographic developer applies it.

Diazo materials have been experimented with as print material for photographic uses,[3] and even the simplicity of processing has not completely offset the low sensitivity and the short tone scale. Its success here has been in reproducing the sound track used in optical methods of sound recording.[4] Its ability to produce high resolution has been given as a great advantage here. However, the newer magnetic-tape methods of sound recording appear to be better at the present state of our knowledge.

As an example of what has been done with diazos, one fascinating attempt to improve this material, especially in its sensitivity, has been that worked out by the Philips organization of Holland and described in detail in the *Journal*.[4] Here, the low cost of the diazo material and its great resolving power are made use of, and the lack of sensitivity is partly overcome by combining with metal systems of mercury or cadmium, and by using silver and other materials in the "development." However, technical difficulties have yet to be completely overcome, and the process has not yet been put on the market. We will not take time here to discuss it in detail since it has already been well described in our *Journal*, as well as in other publications.[4,5]

A related system is that employing the diazo sulfonates,[2,6] which differ from the diazo system in that they produce a negative-type image such as we are familiar with from silver salts. The other interesting aspect of these compounds is that some of them are developable by the application of heat,[7] rather than by chemical reactions of separate developers. However, these compounds do not appear to be as sensitive even as the diazo compounds themselves, and there is great difficulty in trying to make papers or film materials with them which are stable enough to store or ship.

Brief mention should be made here of the dye-bleach color systems,[8] such as those used in such color photography methods as the early types of Gaspar color and others, which have been amply described in our own *Journal* and corollary literature. Here again we have the difficulty of sufficient sensitivity for original taking-film, but the materials have been applicable to making prints from negatives produced by using other processes.

Of course, several very old systems that have been used for reproduction purposes are those like the gelatin-dichromate[9] system, or its cousins, wherein there is a differential hardening of a gelatin or other colloidal layer by the action of light, which affects the ink-receptivity of the layer.[9a] These systems are the mainstay of the printing trades today and they are exceedingly useful in many ways, but they have a low sensitivity and require arc-light exposures, as well as freshly coated material prepared just before exposure. Recent

attempts have been made, some successfully, to utilize diazo-type compounds in printing-plate materials[10] in order to obtain presensitized plates which can be prepared and stored for some time before use. These still, however, require strong light sources and long exposures. All these systems require the use of a "screen" in order to reproduce tones, which limits their usefulness.

In somewhat the same field, fall the various differentially hardened plastics and resins,[11] and the old methods utilizing such materials as bitumen and pitch. As a matter of fact, some of the very old photographic processes antedating the daguerreotype utilized such systems[12]; however, they required exposures to sunlight in terms of hours, and did not give a very stable result.

An interesting variation of this idea is a recent report from a German experimenter[13] of the fact that the use of a tanning developer such as catechol, on a silver halide emulsion in gelatin will produce shadow detail in the gelatin itself in areas beyond those which receive the weakest silver image upon development. It is proposed to make use of this by dying the gelatin and then washing away the unhardened lesser-exposed areas with warm water, leaving a silver image, together with this dye-plus-gelatin image, which combines to make a denser negative, especially in the very weak shadow regions. This would, of course, require a special type of emulsion and additional special treatment which, though it appears to be capable of greater sensitivity than the silver methods normally used, requires extra care and treatment in processing which makes it difficult of application.

Salts of various heavy metals such as lead,[14] thallium,[15] selenium[16] and many others have been used to form photographic images, such as were also formed in an experiment during the late war by one military man who used the familiar trinitrotoluene or TNT to make a photographic image.[17] He did this by coating paper with a solution of TNT, drying it and exposing it to light. In all these cases the sensitivity so far appears to be very low, and no method of increasing the sensitivity has yet been reported.

One rather surprising nonsilver system has recently been proposed which is brought to mind by the use just mentioned for TNT. This is the use of explosive materials to form an image by the results of the explosion. In a recent report the use of nitrogen triiodide is described. This is a ticklish material which many of us used to use in schooldays for practical jokes; it will explode with great noise when slightly disturbed, even when tickled with a feather. In this case, the light falling on it through a lens is sufficient to set off an explosion, and an image is left on the support, burned in by the explosion.[18]

The light-sensitive glasses developed by the Corning Glass Works[19] are of interest, especially as they will give some colors as well as black-and-white images, but they are not practical for motion picture engineering use because of the fragility of the base material, the special processing (requiring very high temperature fusing) and other difficulties, which we understand also include a low sensitivity. The colors obtained are not "natural" colors as in Kodachrome, etc.

On the other hand, quite interesting advances have been made with various processes of electro-photography, such as have been developed at the Battelle Memorial Institute in connection with the work of Haloid Co. under the name of Xerography.[20] Further work on this has been done at the Signal Corps Engineering Laboratories (Squier Signal Corps Laboratory) at Fort Monmouth, N. J., and reported in the recent literature.[21] They appear to have overcome the early difficulties of poor tone-scale

reproduction, and we have seen portraits made by this process which had fairly good quality.

The process basically involves the "sensitizing" of a prepared selenium plate by giving it an electrostatic charge. Upon exposure to light, in our case to an image, the resistance of the plate drops in the higher exposure regions, so that the charge there is less. Development consists of dusting on a dry powder which clings to the areas still holding the most electrostatic charge. This powder image may be fused to permanence by heat, or transferred to another paper support and then fused. Three to five seconds in a photographic dry mounting press will do the trick. The plate itself can then be cleaned and re-used for another picture. The great advantage here is the speed of processing and the fact that it is an all-dry system without water solutions. However, the manipulation by the operator including the preparation of the plate just before exposure, whether of selenium or of phosphors[22] (both of which systems are used), is quite difficult and delicate, and a high-tension electrical system is necessary to utilize this method. It gives a direct-positive result, and does not as yet appear to be applicable to a negative-to-positive system. However, a great deal of work is being done on it for the various applications such as photocopy work, special Air Corps cameras, and even for X-ray use,[23] and to prepare lithographic printing plates.[24]

Another interesting process announced fairly recently, is that referred to as thermography,[25] exemplified by the heat copying process, recently announced by the Minnesota Mining & Mfg. Co. In this process, called Thermofax, the image is formed by an infrared or heat exposure which melts a waxy material where inked areas concentrate the heat, and the resulting image on a special paper is both a positive and a negative. This may be rather confusing, but the fact is that as a result of this exposure you get a print on a semi-opaque paper which by reflected light looks like a positive, since the exposed areas are darker than the chalky blue-white background (of the example we saw). However, when viewed by transmitted light, those exposed areas become a transparent light blue against an opaque whitish-blue background, and form a negative image which can be used to make prints by usual contact printing methods on silver-salt materials. This appears to have interesting applications for office photocopy use, and this is the first commercial application being worked on. However, it requires exposure to heat, or infrared rather than visible light rays. It does not appear to have a great deal of tone range, and it appears to be very slow, as with so many of these nonsilver systems; therefore, as presently described, it does not appear to have any application at all for our present purposes.

Conclusions

Having now discussed and described some of these proposed light-sensitive systems, the question is, Where do we go from here?

It would seem that each of these systems, which we have so briefly examined, has at least one great shortcoming in comparison to the silver-salt process we are so familiar with. They all appear to have a low sensitivity to light. Many of them appear to have a poor tone range, and some of them seem to require even more complicated processing techniques to produce the final image.

It would therefore seem that, as presently developed, none of these systems has any immediate direct application to motion picture photography, that is in preparing either the positive print or the negative film from which the positive is printed. There are a few cases, such as the Philips diazonium system, which appear to have some promise for making prints. This is also true of

some of the dye-bleach color systems such as early Gaspar color. In a few cases the low sensitivity is not so important. But where the sensitivity has been even somewhat increased, the cost of the material is no longer low, and therefore such a system is less competitive with the silver-salt process than it was originally.

Of course, in auxiliary aspects of our work, some of the nonsilver processes can be used but not in a direct, motion-picture-taking application.

But what of the future? Can some of these processes come up to the overall advantages of the silver process? A close study of the literature in a number of these cases, and first-hand experience with a number of these processes in the laboratory, indicate that they have a long way to go before any of them could successfully challenge silver for more than a small part of silver's great range of usefulness. For example, we have had an opportunity to watch an investigation recently of claims to a new process by which the sensitivity of a diazo dye process was to be increased to equal that of silver materials. When it was finally boiled down it was found that the sensitization simply did not work. Applied to textiles, this special type of diazo process was quite practical, but it required terrifically long exposures or exposures to extremely bright light at very close range, and it required exposure of the material while wet. So, another hopeful method of speeding up one of the nonsilver processes went by the board.

In general, our present conclusion must be that none of these other processes is likely to become competitive to the silver process in the near future, for our purposes. In some specialized fields, such as photocopy work, and other cases where high exposure speed and good tone range are not necessary, there is great hope that some of these methods will give results equal to that given by silver emulsions at lower costs and with simpler processing techniques, but with the very high requirements of the motion picture art, we of this group cannot expect much from any of these "new" systems for a long time to come.

Therefore our major efforts at present should be expended on improving the processing technique of the silver process in order to simplify it, and lower the cost. Some of these methods appear to be very promising, such as the stabilization techniques to replace the fixing and washing stages of normal silver processing. The use of higher temperatures, spray processing procedures and other improvements in this aspect, will decrease some of the few disadvantages of our familiar and very successful silver light-sensitive process.

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Discussion

Wm. H. Offenhauser (*Consultant*): In among some old film clips that I had a number of years ago, there was a strip of diazo process film that was printed in France. The picture was *Dreyfus*. I lost its history from that point on. I wonder if you can tell us why the thing died or why it might have started at all.

Thomas T. Hill: There was a lot of promise in that process. Of course, the diazo system is promising because you have colors there and they thought they could make use of it. Also it's nongelatin. Actually the sensitive material is cast right into the base, whether it's a celluloid base or a cellophane base. Most of the sound-track methods were on a cellophane base like the Philips diazonium process. One of the drawbacks was that you did not have the dimensional stability and the overall usefulness of your prints running as many hundreds or thousands of times as does a good print from material we use now.

Another trouble was that these diazo dyes were not as light stable, and after projection a few dozen times the image began to fade. It's very difficult to get good fixing with diazo materials — so nothing intensifies or darkens, and so that the dyes do not fade. That seems to be why that thing has fallen by the wayside up to now. There's still enough promise, I think, to continue with it, but it isn't as good as was hoped for in the beginning.

Anon: Is there anything in the literature that would indicate the problems of sound recording on these nonsilver media?

Mr. Hill: That was one of the applications that the Philips diazonium process was aimed at, because of its terrifically high resolution — they thought they could get a better sound track. But when I talked to the men who had worked on it in this country they told me that they had found several things wrong with the thing as developed in Holland and sent it back for further research. One of the troubles was that they spent all of their time working on a material on a cellophane base. Because of the very thinness of the material they could put a big reel of film with sound track on a very small area, but the people in this country pointed out that the dimensional stability of the cellophane wasn't up to what we're used to in the motion picture industry and it just simply wouldn't work for that reason.

The other thing was, of course, the mercury involved a health hazard which they apparently hadn't realized. So it has gone back to Holland for work with the cadmium aspect of the system and Dr. Jamieson of the Philips Laboratories in Irvington-on-Hudson, New York, told me recently that there's some promise that they'll come back again with better results for that specific purpose on sound track.

Anon: So the summary is probably that Eastman Kodak and du Pont and Ansco can continue to make film for a little while?

Mr. Hill: For quite a while.

Anon: Until the magnetic boys catch up with them.

Mr. Offenhauser: I'd like to bring in a little more history at this point. Just before World War II when I was with John Maurer we were working with a wide-range silver film master record recording system for frequency modulation broadcasting. We used Class A push-pull, direct-positive recording on yellow-dyed silver film with galvanometers that peaked at 22 kc and with a film speed of 60 ft per min. The direct-positive was printed in diazo material by Agfa-Ansco at Binghamton.

We made prints on diazo material and the objective at that time was to use the prints from these records for FM stations as transcription record material on account of the fact that we found very low distortion levels in the diazo prints from the silver originals. I mention this as a matter of history.

Mauro Zambuto (*Scalera Films, Rome, Italy*): One advantage of those diazo films was that they scratched less in some aspects of them. In connection with the sound-track use of the diazo materials, I wish to say that I also had some experience with that particular film that was made in France, and incidentally it was *Dreyfus*. That was back in 1939. Now, there was one major problem at the time due to the

fact that the diazo materials never seemed to reach a very high density. So in this particular instance, the most trouble they had was with the signal-to-noise ratio. I would like to know if in the new experiments anything better has been achieved.

Mr. Hill: There has been a good deal of work done on that aspect simply for the office copying use of diazo on paper in trying to get a better and more opaque black, and I'm sure that some of those things have given us combinations of dyes which are better than we had, say, twelve or thirteen years ago. It is that total density that they're trying to improve, but as with any of the dyes, where you have a black dyestuff for cloth or any other purpose, you really have a very dark color rather than a true black. In the same way with the diazo coupling, and as I mentioned before, there is a faint fading going on so that when you've got a total density that's still a little less than you want and then it starts to fade, you've still got trouble. But I'm sure that some of the dyes that have been worked out in the past four or five years are much better than they've had before.

Mr. Zambuto: Could you give us any figure as to the amount of signal-to-noise ratio that was achieved?

Mr. Hill: In that case I can't. The stuff I have seen has been on paper materials. We've been involved in the basic chemicals rather than in the application, so that we don't have that part of it going through our lab. But we do have the basic chemicals and their coupling to get a black, black as possible on paper.

Mr. Offenhauser: As I remember it, we had something like 60-db signal-to-noise ratio and something less than 2% harmonic distortion. The figures can be obtained, I believe, from Andre Schoen in Binghamton; he has the logs and test data. We would never have contemplated using these materials for FM transmission unless the performance was that good or better. We used blue-sensitive photocells with matching dyes; these latter were peaked in the same general spectral range. We tried many dyes and cells experimentally; the blue combination proved to have the best performance at the time.

72d Semiannual Convention

Hotel Statler, Washington, D.C. October 6–10

Wheels have been turning for the Washington Convention ever since the Editorial-Papers Committee Meeting at Hollywood last October. In addition to specific plans for last April's Chicago Convention, general plans were laid for a year ahead and Joe Aiken, Papers Committee Vice-Chairman for Washington, D.C., was welcomed and was promised cooperation from all present in his job as Program Chairman.

The 72d Convention, even in its present, embryonic form, is proving again the worth of the practices and procedure worked out over the past few years by Papers Committee Chairman Ed Seeley. It used to be that the Papers Committee Chairman organized the technical papers program on his own primary responsibility and also almost completely by his own efforts. Not only was this a great burden on the same individual twice a year but also it was apparently less effective than having someone in the convention city responsible for the program; so Ed Seeley set up the title and function of Program Chairman. The Program Chairman is the Papers Committee Vice-Chairman in the convention city. General advice and carry-over information go to the Program Chairman from the Papers Committee Chairman and also from the Program Chairman of the previous convention. The Society's headquarter's staff assists only by trying to assure mutual understanding by all concerned and by channeling suggestions which come from divers members. The Editorial Vice-President is responsible to the Society's Board of Governors for the function of the Papers Committee and so, also, for the technical sessions of conventions. The Editorial Vice-President's convention role, as most recently exemplified by John Frayne, is that of being helpful only when called upon specifically and by using his special and good offices to obtain special papers or initiate plans for particular sessions.

Leads, suggestions, or finished papers may originate with any interested person — but all paper possibilities should be channeled through a Papers Committee member. The Papers Committee Vice-Chairman in the area should be kept informed of the development. Papers Committee members and vice-chairmen are responsible for initiative in their respective companies or areas.

For the Washington Convention, Joe Aiken will also be Local Arrangements Chairman, assisted by a roster of Washington folks who were nearly all appointed at a meeting in Washington on May 29 when Convention Vice-President Bill Kunzmann was in Washington to make convention plans and commitments. The list of those responsible for the many duties and functions will be published in the August *Journal* — but this does not mean that there is no room for more helpers or suggestions, particularly for research, techniques or new products manuscripts. These should preferably be channeled through the Papers Committee Vice-Chairman or member nearest you. The complete Papers Committee is:

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Three special sessions have long been scheduled for the Washington Convention: (1) an international symposium on high-speed photography for as much as two full days' sessions, some or all of them concurrent with other sessions; (2) a session on magnetic striping of film; and (3) a session on maintenance of 16mm equipment. More details about these and other sessions will be given in next month's *Journal*. On August 6 all members will be sent the Advance Notice of the Convention. This is the usual folded postal mailer which gives the schedule of sessions and includes a tear-off postal for making hotel reservations.

Engineering Activities

Status of Proposed Standards: In the past year or so quite a few proposed standards have been published for trial and criticism. The status of these is outlined below to bring all concerned up to date.—*Henry Kogel*, Staff Engineer.

Title	PH 22	Date pub.	Status
Cutting and Perforating Dimensions for 35mm Motion Picture Film — Alternate Standards for Either Positive or Negative Raw Stock	.1	9/51	Approved by Standards Committee. Now out to letter ballot of ASA Sectional Committee PH22.
Emulsion and Sound Record Positions in Camera for 16mm Sound Motion Picture Film	.15	12/51	Further revisions have been proposed which are now being considered by the 16 and 8mm Committee.
Emulsion and Sound Record Positions in Projector for Direct Front Projection of 16mm Sound Motion Picture Film	.16	12/51	
Screen Brightness for 35mm Motion Picture	.39	5/52	Trial period ends Aug. 15. No Adverse comments received as yet.
A & B Windings of 16mm Raw Stock Film with Perforations Along One Edge	.75	1/51	Adverse comments were received. Several new drafts have since been proposed by 16 and 8mm Committee to resolve the differences. The latest is now going out to letter ballot of the 16 and 8mm Committee.
Edge Number 16mm Motion Picture	.83	1/51	Approved by PH22. Must next be reviewed by SMPTE Board of Governors for Sponsor approval.
Dimensions for Projection Lamps Medium Prefocus Ring Double-Contact Base-Up Type for 16mm and 8mm Motion Picture Projectors	.84	2/51	Approved by Standards Committee. Now out to letter ballot of ASA Sectional Committee PH22.
Dimensions for Projection Lamps Medium Prefocus Base-Down Type for 16mm and 8mm Motion Picture Projectors	.85	2/51	
Enlargement Ratio for 16mm to 35mm Optical Printing	.92	1/52	

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal.*

Letters to the Editor

Re: Three-Dimensional Motion Picture Nomenclature

I have read with great interest Major Bernier's article on "Three-Dimensional Applications" which appeared in the *Jour. SMPTE, 56:* 599–612, June 1951.

Major Bernier is to be congratulated on his paper and also on the interesting experimental work which he and his unit are conducting. The writer would, nevertheless, like to draw attention to a few points in the paper in connection with which there seems to be some confusion.

On page 599 in the *Journal*, reference is made to "the composite or lenticulated system," but just what Major Bernier is endeavoring to convey by this terminology is not clear. There are three main groups of processes (embracing hundreds of different modes of application) which might conceivably, but should not, be referred to in this way. These three groups comprise: (1) integral processes, which had their genesis in the idea conceived by Gabriel Lippman and disclosed by him in 1908 (*Compt. rend.*, *146:* 446–51); (2) parallax stereogram processes, all of which are derived from the principle described in Frederic Ive's U.S. Pat. 725,567 (application date, Sept. 25, 1902); and (3) parallax panoramagram processes, which depend on the principle of C. W. Kanolt, described by him in his U.S. Pat. 1,260,682 (application date, Jan. 16, 1915).

The problems involved in producing spherically lenticulated film as proposed by Lippman were not solved during the inventor's lifetime, but the earliest practical process (for still photography) employing a cylindrically lenticulated screen with which the writer is acquainted was described by Walter Hess in 1911 in his Brit. Pat. 13,034.

The most important of Dr. Herbert Ive's ideas relating to stereo kinematography are those embodied in Brit. Pat. 348,118 (application date, Feb. 7, 1930) and his corresponding U.S. application (convention date, Feb. 9, 1929). Very many other processes involving the use of line or lenticular grids, for both still and motion pictures, were evolved between 1911 and 1929.

In discussing, on page 601 of the *Journal*, the various factors contributing to depth perception, Major Bernier has again departed from accepted terminology, and this may be confusing to some with limited knowledge of the subject. For example, factor No. 4, in Major Bernier's list should read "Accommodation," not "Focus reaction," and factor No. 6 should read "Binocular vision," not "Stereoscopic vision."

The word "stereoscopic" means (freely translated from the Greek), of course, "seeing solid" or, as we are accustomed to say, three-dimensionally or stereoscopically. Accordingly, the term "stereoscopic vision" applies to the net effect resulting from the various contributory factors. In compiling a "short list" of these factors, it is, in the writer's opinion, difficult to improve on the custom of dividing them into two groups: (1) monocular factors; and (2) binocular factors. In the first group the chief factors are accommodation and perspective, and in the second group we have parallax and the faculty of convergence. There are numerous subsidiary factors, some of which are mentioned by Major Bernier.

Referring to the comments in the second paragraph of page 601, whilst it is, of course, true that accommodation becomes of decreasing importance with increasing distance of the object, neither this fact nor any other warrants definition of a distance of 20 ft as "optical infinity."

The reasoning on the next paragraph of the paper is based on a fallacy. It can best be demonstrated experimentally that the faculty of accommodation is stimulated practically always when one is watching projected motion pictures. The apparent size of the image is no less important than the distance of the screen in determining the degree of stimulation. Let us suppose, for example, that the film being projected depicts an object moving toward or away from the observer so that it is progressively either increasing or decreasing in size. If the object depicted is a familiar one, and the apparent size of the image corre-

sponds to a distance within the normal range of accommodation, the eye will attempt to accommodate for that distance. This momentarily throws the screen out of focus, so the eye then re-accommodates for the plane of the screen. If, by that time the image of the object — assumed to be still moving — is at a different "apparent" distance within the range of accommodation, the eye will attempt to accommodate for the new distance, thereby again throwing the screen out of focus. This cycle of events recurs with great rapidity, and is sometimes the cause of headaches amongst elderly cinema patrons, whose ocular sensory organs and muscles are, naturally, less responsive than those of younger people.

With regard to the main subject discussed in Major Bernier's paper, namely, the development of alternate-frame stereo techniques, it is, perhaps, worth drawing attention to the fact that the majority of the basic problems involved were investigated in England by the writer, Edwin Wright and others several years ago. Work on such processes has been abandoned by most workers in this country, mainly owing to recognition of the fact that the disadvantages resulting from "time parallax" are inherent in all alternate-frame systems.

There are several known methods of overcoming the flicker problem, that developed by Wright being as satisfactory as any; the writer considers it preferable to the use of the more complex Morgana shuttle movement. A description of Wright's method is given in the writer's book, *Stereoptics — An Introduction*, Macdonald & Co. Ltd., London, 1951.

Major Bernier's comments concerning the flicker problem are made somewhat difficult to follow by this use of phrases such as "a flicker frequency of 72 frames/sec, or 36 frames/sec per eye," which do not really convey what the author intended, as the important matter is the number of *occultations* per second rather than the number of frames.

To understand the nature of the flicker problem it is essential to appreciate that with any projection system, whether stereoscopic or planoscopic, the rate of flicker per second is equal to the number of times per second that light is occulted from each eye. Thus, in ordinary planoscopic projection, the flicker rate is equal to the product of the number of frames projected per second and the number of blades in the shutter. When projecting planoscopically at 16 frames per second, for example, the flicker rate is 32 or 48 per second according to whether a 2-blade or 3-blade shutter is employed. In neither of these two cases is flicker perceptible to the eye, so the term "flicker" is really a misnomer in such instances. It is readily demonstrable that the minimum rate of occultation necessary to prevent the occurrence of objectionable flicker is about 24 frames/sec, this rate being achieved at a projection speed of 12 frames/sec with a 2-blade shutter or 8 frames/sec with a 3-blade shutter.

Now, with stereoscopic systems of the type in question, light is occulted from each eye every time a picture intended for the other eye is projected. This means that in addition to the faster, imperceptible occultations produced by the shutter, there occur occultations at a slower rate numerically equal to one-half the number of frames projected per second. Accordingly, in order to provide the necessary minimum of 24 occultations per second for each eye, a projection rate of 48 frames per second must be adopted, regardless of the number of blades in the shutter. As this is generally impractical, it becomes necessary to adopt some arrangement such as those used by Wright and Major Bernier. The writer ventures, nevertheless, to express the opinion that such arrangements are not really worth while owing to the facts that "time parallax" errors are still present and that the apparatus is somewhat complex. He would like, in conclusion, to draw attention to the new single-film polarized light process some particulars of which are given in his paper "Stereoscopy in the Telekinema and in the Future," which appeared in *British Kinematography, 18, No. 6:* 172–181, June 1951. This would appear to be the most satisfactory polarized light process so far developed.

August 30, 1951

L. Dudley
Odeon Theatre
Kensington High St.
London, W. 8,
England

Reply to the Letter Above

The recent letter by Mr. L. Dudley, director of the Laboratory, Odeon Theatre, London, indicates his confusion in reading my paper "Three-Dimensional Motion Picture Applications," published in the June 1951 issue of this *Journal*. I would therefore like the opportunity to set forth in more detail the explanation of certain phraseology and certain technical aspects with which Mr. Dudley was confused.

He points out that "there are three main groups of processes, which might conceivably, but should not be referred to as the "composite or lenticulated system," as I did on page 599 in the *Journal*. Although he listed the three main groups, he didn't give any indication of how that type of three-dimensional photography could intelligently be referred to. As I see it, each of the groups has one thing in common: namely, that a viewing device on or near the eyes is not needed to vision the three-dimensional results. Each depends on a medium near the picture surface to selectively direct the proper views of the subject to their respective eyes. To produce a stereoscopic vision in the brain, this medium is dependent, in all cases, on one basic fact, that the eyes are displaced. Since the groups, as Mr. Dudley refers to them, are therefore more or less related, there should, in my opinion, be some definite means of referring to them.

I could not find anything in the literature which seemed to suitably express this phase of stereoscopy, and as a result chose to refer to the latest refinements of it as the "composite or lenticulated" system. As to the source of the expression "composite," it appears in the reference book *Medical Physics*, edited by Otto Glasser, Ph.D., Year Book Publishers, Inc., Chicago, 1944–1950, on page 1326 in a treatise on three-dimensional photography. The article under a paragraph heading "Trivision" reads "Early in 1941, the Winnek Laboratory introduced a new process of composite stereography, now called "Trivision." Composite photography, as defined in Webster's New International Dictionary, means a photograph or portrait made by a combination, or *blending* of several distinct photographs, either made one over the other, or made on one print from a number of negatives." This, in my opinion, comes very close to describing the condition that exists in the present picture emulsion of the French "Portrait en Relief," the British "Deep Pictures," or the American "Trivision," and other trade processes, all of which stem from the pioneering efforts of H. E. Ives (1902), Lippman (1908) and, of course, Berthier (1896).

These refinements of which I speak, consist in segregating and resolving (within limits), by means of a lenticulated surface in front of the emulsion, a continuous changing view, or an infinite number of views of the subject. Thus, when the composite picture is viewed through the same or an identical lenticulated surface, left and right views are selectively projected to their respective eyes. Reasonable freedom of movement of the viewing position either laterally or perpendicularly to the picture is possible, because any two views of the composite, within the angle of coverage of the lenticulation formula employed, will always be a left and right view of the subject, and will be directed to the left and right eyes, respectively.

The reason, thus, that I referred to this phase of three-dimensional photography as the "composite" or "lenticulated" system is because, in my opinion, this phraseology most adequately describes this process of three-dimensional photography which in turn has enjoyed limited recent popularity as a result of a more efficient combined use of these two basic features.

I chose to use "Focus reaction" rather than "accommodation" in listing my interpretation of the basic factors of depth perception, because it seemed to me that this expression would be more easily understood by the layman, rather than the more technical expression "accommodation," used almost exclusively in ophthalmic practices. Also, I intended to imply that it is not, in my opinion, the difference in the character of the focus of objects which notifies the brain of their relative positions in space, but on the other hand the reaction due to the tensing of the ciliary muscles.

In connection with my use of "Stereoscopic vision" as the sixth factor, instead

of the commonly used phrase "Binocular vision," I reasoned that it is possible to use "two eyes" in certain cases, but not to be able to see stereoscopically. For example, the conventional binocular microscope has two oculars, but only one objective; and thus when using such a microscope binocularly, one does not see stereoscopically. This is also true of some binocular viewers for single Kodachrome transparencies; also when viewing any single photograph or painting binocularly the subject matter cannot be seen stereoscopically. Thus it would seem that the only requirement to actually view subject matter stereoscopically is to change the angle of convergence of the eyes for different planes of depth.

We view present two-dimensional color motion pictures on the screen with both eyes, or binocularly, but we cannot see the subject matter stereoscopically because of the absence of the requirement to change convergence for different planes of depth. This would be a case where all the factors that Mr. Dudley would like listed could be activated, but we still could not see the subject matter stereoscopically. This is the reason I chose to use "Stereoscopic vision" rather than "Binocular vision" as the sixth factor of depth perception.

It seems to me that his reasoning "that stereoscopic vision is the net result of the various contributing factors" is based on a fallacy. Stereoscopic vision is achieved in the "Anti-Aircraft stereoscopic height finder" without any of the contributing factors Mr. Dudley mentions, except the "faculty of convergence." The determination of the slant range of aircraft in this case, depends solely on this factor, and as I chose to say "Stereoscopic vision."

In connection with Mr. Dudley's objection to my use of the expression "Optical infinity," and that I indicated that it could be considered as 20 ft, I would like to point out that this is a common expression in the field of ophthalmology and optometry, and to all American trained optometrists the expression immediately suggests 20 ft, since this theory for many years has been and is being taught in American colleges and universities (see textbook *Outline of Optometry* by I. M. Borish, page 36, Sec. 8 A1, or *Physiological Optics* by W. D. Zoethout, 4th ed., Professional Press, Inc., Chicago, 1947, page 38, paragraph titled "Principal Foci.")

The next paragraph of my paper, contrary to Mr. Dudley's opinion, is based on the fact that there is a direct relationship between accommodation and convergence. Namely, that when converged at a certain distance, the eyes in a normal individual will also automatically focus for that distance and vice versa. This relationship is thoroughly discussed on pages 431 and 432 of A. C. Hardy and F. H. Perrin's *The Principles of Optics*, first edition, ninth impression, Camera Craft Publishing, San Francisco, 1943. Thus, if what Mr. Dudley says is true it would seem to me that referring to the examples he gives of a film depicting objects moving toward or away from the observer, that the eyes would also want to change convergence. If they change their convergence to follow the apparent position of this moving object, the result would be double imaging. This also should occur "with great rapidity," but I don't believe it does. I maintain, as indicated in my paper, that as long as subject matter in the three-dimensional motion picture appears no closer than 6 or 8 ft from the observer, accommodation errors will not result. I cannot agree with Mr. Dudley on the cause of headaches amongst some older people who go to the movies, since it is common knowledge in ophthalmic practice that they lose their power of accommodation as a result of progressive hardening of the crystalline lens as they grow older. This would indicate to me that as long as they were wearing glasses corrected for the screen distance, the subject matter on the screen would remain always in focus. Therefore it is interesting to note that when this be the case, especially with three-dimensional motion pictures, they will see subject matter clearly even when required to converge on three-dimensional screen objects, which could conceivably appear as close as two or three feet in front of their faces. As an added prediction, they will quickly realize that for such a phenomenon, they will not need to "peer" through their "bifocals."

I prefer not to disclose as yet what improvements have been made in connection with the alternate frame system. However, I would like to assure Mr. Dudley that the

"time parallax" problem has been completely solved, and that the alternate frame principle with the latest modifications shows promise, in my opinion, of being the most all-around satisfactory stereoscopic motion picture method to date.

In regard to my use of the phrase "a flicker frequency of 72 frames/sec, or 36 frames/sec per eye," I would like to clear up Mr. Dudley's apparent confusion in respect to the action of the Morgana movement. This movement, I made quite clear in my paper, actually transports frames of film in and out of the film gate at the rate of 72 frames/sec. This rate of frame transport is, therefore, exactly coincident with the shutter-blade rate, and therefore is also identical to the total "occultation" rate. Thus the right frames, for example, are transported in and out of the film at the rate of 36 frames/sec, which also equals the "occultation" rate for that eye, per second. Since, then, the actual framing rate is also equal to the flicker rate, I believe it reasonable to express the flicker frequency in terms of "frames per second." As I pointed out in my paper, since every third transport consists in moving a "frame backwards" out of the gate, the net result is a "progression of the film through the projector at standard sound speed."

Again I cannot agree with Mr. Dudley's contention that "the minimum rate of occultation necessary to prevent the occurrence of objectionable flicker is about 24 per second." If this were true it would not be necessary to use a two-bladed shutter in standard theater-type projectors, which in turn doubles the occultation rate with respect to the "24/sec" frame rate.

When the film *3 D Motion Pictures* was screened at the SMPTE 1951 Spring Convention, some may recall that there still remained some flicker. This was due to the comparatively slow flicker frequency of 36 frames/sec per eye. This frequency was somewhat objectionable, and to bring it up to present standards, improvements had to be made. A new projector, which will incorporate important changes will be ready to demonstrate in the near future.

November 14, 1951

Robert V. Bernier, Major, U.S.A.F.,
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Dayton, Ohio

Obituary

Charles Ross died in June at the age of 63. He was President and sole owner of Charles Ross, Inc., a business which he started 30 years ago.

He began working for motion picture studios in New York City when a boy, one of his early employers having been the Biograph Studios. He was an electrician and he gradually built up stocks of everything from cables to equipment which eventually included every type of lighting or grip equipment for motion picture production.

He was educated in the New York public schools and some time after he had begun his business he and Pete Mole discovered in mutual reminiscing that they had grown up in the same New York City neighborhood and gone to the same schools without then being acquainted. Charles Ross, Inc., has now for long been sole eastern agents for Mole-Richardson equipment. The firm's headquarters at 333 W. 52 St., New York 19, N.Y., is in the same neighborhood where Mr. Ross had offices and warehouse during his decades in business.

Besides being an Active Member of this Society, Charles Ross was a member of Motion Picture Pioneers, Theatre Equipment and Supply Manufacturers' Association, Stage Employees' Local #1 of the IATSE and Motion Picture Studio Mechanics Local #52 of the IATSE.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 Membership Directory.

Honorary **(H)** Fellow **(F)** Active **(M)** Associate **(A)** Student **(S)**

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Hughes, Dale E., Film Producer, 186 E. Center St., Marion, Ohio. **(A)**

Jaeger, Donald J., University of Southern California. **Mail:** 2300½ Cahuenga Blvd., Los Angeles, Calif. **(S)**

James, Stanley L., Projectionist and Sound Technician, United Amusement Co. **Mail:** 6 Carolina St., S., Hamilton, Ont., Canada. **(A)**

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Kellum, Theron O., Re-recording Mixer, RKO Radio Pictures, 780 N. Gower St., Hollywood 38, Calif. **(M)**

Kezer, Charles F., Engineer, Fairchild Recording Equipment Corp., 154 St. & Seventh Ave., Whitestone, N.Y. **(A)**

Kudar, John C., 1809⅜ Las Palmas Ave., Hollywood 28, Calif. **(A)**

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Lewis, Herschell G., Radio-TV Productions, Lewis & Clark, Inc., 1020 N. Rush St., Chicago 11, Ill. **(A)**

Liebers, Harold A., 307 Martense St., Brooklyn 26, N.Y. **(A)**

Lindsay, Leslie C., Audio and Television Technician, Leslie C. Lindsay & Associates. **Mail:** Steeles Corners, R.R. #1, York Mills, Ont., Canada. **(A)**

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CHANGES IN GRADE

Atkinson, R. B., **(A)** to **(M)**
Beard, D. M., **(A)** to **(M)**
Bernard, H., **(S)** to **(A)**
Blaney, Dorothy, **(A)** to **(M)**
Flory, John, **(A)** to **(M)**
Pfahler, R. A., **(A)** to **(M)**
Riley, L. W., **(A)** to **(M)**

Book Reviews

Proceedings of the National Electronics Conference, Vol. 7

Published (1951) by National Electronics Conference, Inc., 852 E. 83 St., Chicago 19, Ill. 736 pp. incl. numerous charts, diagrams and tables. 6 × 9 in. Price $5.00.

This volume consists of the papers presented at the seventh annual National Electronics Conference held in Chicago in the fall of 1951. The topics presented cover just about the entire field of modern electronics as can be seen by the subsequent listing of subjects, and are extremely timely to anyone working in the field. Your reviewer found at least a dozen papers that had direct bearing on immediate problems.

The subjects covered include servo theory, electron tubes, information theory, audio systems, signal detection, components, high-frequency measurements and propagation, computers, magnetic amplifiers, circuit analysis, industrial electronics, television, and medical applications.

The editors of the volume are to be commended for a fine job in taking the numerous papers from different authors on various topics and organizing them so as to maintain continuity, especially in style. This represents a continuation of the good work done in the previous volumes of this series.

The book is printed clearly and the illustrations are very legible.

This well prepared and edited volume of the Conference papers will serve either as a well reported summary to those who were unable to attend the meeting, or as a convenient reference volume for those who were there. It would be very desirable if other major conferences would publish similar proceedings.—*H. I. Zagor*, General Precision Laboratory, Inc., Pleasantville, N.Y.

Professional Training of Film Technicians

By Jean Lods. Published (1951) by UNESCO, Paris. Distributed in U.S.A. by: Columbia Univ. Press, 2960 Broadway, New York 27, N.Y. 155 pp. $8\frac{8}{9} \times 5\frac{1}{4}$ in. Price $1.00.

A valuable addition to the Press, Film and Radio Series of studies sponsored by the United Nations Educational, Scientific and Cultural Organization, this brochure surveys a field whose importance has only recently been recognized in this country.

Its author is a distinguished French film director, cofounder and Deputy Director-General of the *Institut des Hautes Etudes Cinématographiques*, a Government-subsidized postgraduate school devoted to the teaching of film aesthetics and crafts.

In the ten countries investigated, states Mr. Lods, "professional training is directly conditioned . . . by the situation, organization and tendencies of the national film industry." The latter, he finds, is divided into three main types, depending on the degree of government control.

This control may vary considerably, but the author points out the universally admitted fact that "the quality of national film production is a matter of concern to the entire country." Therefore, national prestige is closely related to the competence of film technicians and their professional training.

In this respect, the high standards of the French *Institut* can be judged by the following question asked at the competitive entrance examination for art directors: "Voltaire's 'smile' is often mentioned. Define and analyze this smile on the basis of *Candide*. Relate it to a frame of mind generally characteristic of the 18th century."—*George L. George*, Screen Directors Guild, 133 E. 40 St., New York 16, N.Y.

Fluorescent Lighting

By W. Elenbaas, J. Funke, Th. Hehenkamp, L. C. Kalff, A. A. Kruithof, J. L. Ouweltjes, L. M. C. Touw, D. Vermeulen and R. Van Der Veen. Edited by C. Zwikker. Published (1952) by N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands. Distributed in U.S.A. by Elsevier Press, Inc., 402 Lovett Blvd., Houston 6, Tex. i-x + 244 pp. + 4 pp. index. 180 illus. + 23 photos. 6 × 9 in. Price $6.25.

The book reviews the scientific fundamentals of the design and operations of fluorescent lamps and accessory equipment, in terms of types and sizes used in Europe. Chapters on fixtures and fluorescent lighting applications are likewise a report of European practice.

The section on color and color renditions is a good summary of the fundamental technology involved. The spectral data on fluorescent sources, however, are based on lamps manufactured in the Netherlands. Motion picture and television engineers will find the book a convenient way to compare European practice with U.S. practice as reported in books and periodicals published in this country.—*C. L. Amick*, Lamp Div., General Electric Co., Nela Park, Cleveland 12, Ohio.

The Recording and Reproduction of Sound (2d ed.)

By Oliver Read. Published (1952) by Howard W. Sams & Co., Indianapolis 1, Ind. i-xv + 708 pp. + 70 pp. appendix + 10 pp. index. 708 illus. 6 × 9 in. Price $7.95.

This volume contains a large amount of information which should be of interest to audio hobbyists and engineers in audio and related fields. The sections on disc recording and reproducing systems are quite complete and magnetic recording is also covered in considerable detail, although no mention is made of recording on "stripe" tracks on 8mm or 16mm films. Photographic recording is barely mentioned. Public address amplifiers and sound systems are treated at some length, as are microphones and loudspeakers.

Much space is given to reprints of manufacturer's bulletins, which may be of interest to those using the particular equipment described. The NARTB Disc and Magnetic Recording Standards are reproduced in full and numerous tables and glossaries add to the usefulness of this enlarged edition.—*Clyde R. Keith*, 5 North Ter., Maplewood, N.J.

SMPTE Lapel Pins

The Society will have available for mailing after September 15, 1952, its gold and blue enamel lapel pin, with a screw back. The pin is a ½-in. reproduction of the Society symbol — the film, sprocket and television tube — which appears on the *Journal* cover. The price of the pin is $4.00, including Federal Tax; in New York City, add 3% sales tax.

Positions Wanted

Photographic Chemist: 3 yr. experience black-and-white and color film laboratory practice and quality control. Familiar with all commercial color processes and sensitometry. Have conducted research in new processing methods. Position desired in research or development on new products and processes. Will relocate. Write M-52, c/o Lichtig, 3758 Tenth Ave., New York 34, N.Y.

Production, TV or Motion Picture: NYU BA in motion picture and TV production; participated in productions as director and unit mgr; experience as motion picture sensitometrist; at present motion picture negative assembler and cutter; worked swing shift while attending college; licensed 35mm projectionist; single, 29, veteran, resume on request; go anywhere. Harold Bernard, 560 Eastern Pkwy, Brooklyn 25, N.Y.

Meetings

72nd Semiannual Convention of the SMPTE, Oct. 6-10, Hotel Statler, Washington, D. C.

Other Societies

University Film Producers Association, Annual Meeting, Aug. 11–15, Syracuse University, Syracuse, N. Y.

Photographic Society of America, Annual Convention, Aug. 12–16, Hotel New Yorker, New York

American Institute of Electrical Engineers, Pacific General Meeting, Aug. 19–22, Hotel Westward Ho, Phoenix, Ariz.

International Society of Photogrammetry, Conference, Sept. 4–13, Hotel Shoreham, Washington, D.C.

American Standards Association, Third National Standardization Conference, Sept. 8–10, Museum of Science and Industry, Chicago, Ill.

Illuminating Engineering Society, National Technical Conference, Sept. 8–12, Edgewater Beach Hotel, Chicago, Ill.

Biological Photographic Association, Annual Meeting, Sept. 10–12, Hotel New Yorker, New York

National Electronics Conference, Annual Meeting, Sept. 29–Oct. 1, Sherman Hotel, Chicago, Ill.

Optical Society of America, Oct. 9–11, Hotel Statler, Boston, Mass.

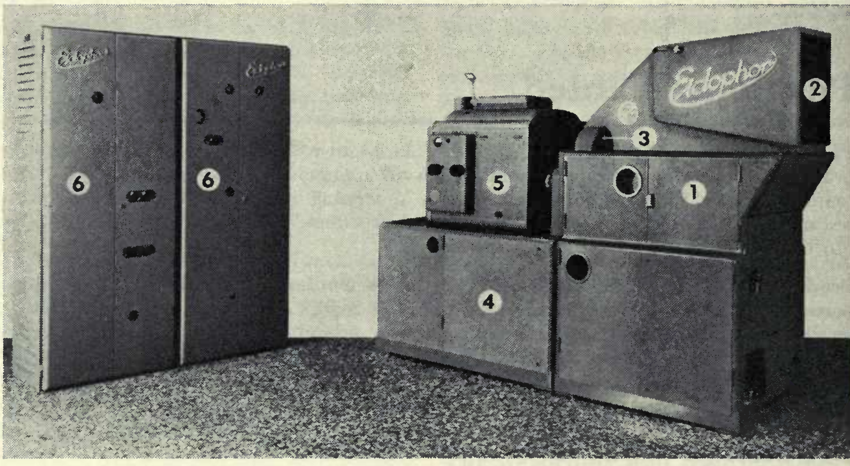
American Institute of Electrical Engineers, Fall General Meeting, Oct. 13–17, New Orleans, La.

American Standards Association, Annual Meeting, Nov. 19, Waldorf-Astoria, New York

Motion pictures in color depend on the engineers' knowledge of the "Principles of Color Sensitometry." A 72-page article bearing that title and prepared by the Color Sensitometry Committee appeared in the *Journal* for June 1950. Attractive reprint copies may be purchased for $1.00.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



Eidophor large-screen, color-television projection equipment: (1) Eidophor projector; (2) projection light beam hood; (3) color wheel; (4) auxiliary services (vacuum pump, thermostat, and system for Eidophor cooling); (5) projection lamp (Ventarc-type); and (6) television receiver circuits.

Eidophor large-screen, color-television projection equipment has been installed in the 20th Century-Fox Film Corp. motion picture theater at 444 W. 56th St., New York City, with demonstrations for the press and invited public beginning on June 25. A 30-min program of great variety and color was originated and transmitted from the sound stages of Movietonews at W. 54 St. and Tenth Ave.

Journal readers may recall the article by E. Labin in the April 1950 *Journal* when the Eidophor was described as occupying two floors. Work toward the Eidophor was described as early as 1941 by Hugo Thiemann and by Prof. Fritz Fischer who directed the project until his death in 1948. The Eidophor was developed at the Polytechnical Institute of Zurich, Switzerland, and was brought to this country in part through the efforts of Dr. Edgar Gretener A.G. of Zurich, and by Dr. Thiemann who was on hand to answer questions during the demonstrations at Twentieth Century-Fox.

The present Eidophor projector is about the size, weight and shape of a standard motion picture projector. The Eidophor has a Ventarc-type projection lamp which was demonstrated at the Society's Convention at Chicago in 1950 and described in the October 1950 *Journal.* The Columbia Broadcasting System's field-sequential color process has been combined with the Eidophor black-and-white equipment. The CBS system was completely described in, among other places, the October 1951 *Journal* by Goldmark, Christensen and Reeves.

Converting the original black-and-white Swiss system to the color demonstrated and getting the present model developed and installed has been under the direction of Earl I. Sponable, with notable assistance from Hubert J. Schlafly, Lorin D. Grignon and William F. Jordan.

Optimum Exposure of Sound Tracks on Kodachrome Films

By ROBERT C. LOVICK

Low-distortion sound tracks on Kodachrome films can be obtained with any conventional exposure method. The best possible sound reproduction requires exposure with light of color quality which correlates the speeds of the individual emulsions when developed to silver sulfide rather than to dyes. Poor sound quality in the past has often been the result of the failure to recognize the critical color quality requirement of the light which exposes the sound-track portion of the film.

Kodachrome Duplicating Color Film, Type 5265 is a 16mm, reversal film designed to be printed from color positives on Kodachrome Films, Daylight Type (5263), Type A (5264), and Kodachrome Commercial Film (5268). The sound-track deposit is silver sulfide. The sound-track record is printed from silver positives prepared according to long-standing recommendations.

The sound process for Kodachrome films consists of three basic steps. First, the silver halides which were exposed in the sound-track printer are developed to a silver negative image. Second, the silver halide which remains is converted to silver sulfide. Third, the negative silver is dissolved, leaving a reversal silver sulfide image.

There are many complicating factors in this basically simple process. For example, the necessity of confining the sound developer to the sound-track area within small tolerances precludes the use of agitation to aid in securing uniform development.

Recent studies have shown that a large part of the stain level of Kodachrome sound records results from conversion of some of the negative silver to silver sulfide. A modified developer which converts a much smaller part of the negative silver to silver sulfide is now being used. There is a small improvement of signal-to-noise ratio which is the result of the increased useful transmission range. The sensitometric effect of the sound developer modification is shown in Fig. 1.

Standardized Printing Methods

Printing to obtain the best possible sound tracks on Kodachrome films requires consideration of three facts. First, the exposures are made on a multilayer film. Second, the three emulsion

Presented on April 24, 1952, at the Society's Convention at Chicago, Ill., by Robert C. Lovick, Color Control Div., Eastman Kodak Co., Rochester 4, N. Y.

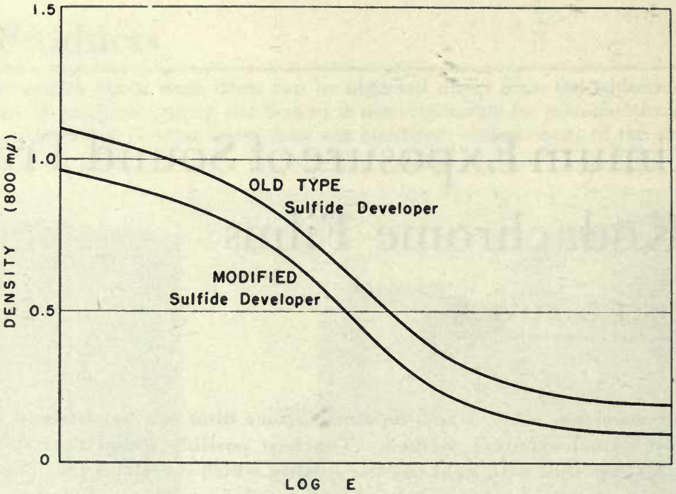


Fig. 1. Sensitometric effect of modified silver sulfide developer.

layers are sensitized to respond principally to three different colors of light. Third, the speed relationships of the layers are determined by the characteristics desired for the dye formation for pictures while sound-track development converts the halides in all layers to silver sulfide, a much different material.

Sound tracks on Kodachrome films are usually printed using a conventional sound printer with adjustments of the printer lamp current to obtain a particular density. Changing the printer lamp current results in the simultaneous change of both the intensity and the color quality of the light source. Since the efficiency of different optical systems varies considerably, and since many different types of lamps and heat absorbers are in use, it is almost impossible to give any information, such as a filter balance, which can be applied without further extensive tests on the particular equipment involved.

Standardizing the light source for sound-track printing requires very little additional control work for most laboratories and makes possible the use of printing recommendations without extensive tests. If conventional distortion tests can be made, there is still a considerable saving of time and film because an excellent starting place is available for adjusting the exposure balance for particular equipment. Should emulsion changes become necessary or desirable, the extent of filter-pack modification could be specified, reducing appreciably the need of additional time- and film-consuming tests.

A fixed color temperature of 2900 K for a tungsten source is suggested because it is well within the rating of most lamps and because experience has indicated that more than enough light is available on almost any printer. Heat-absorbing glasses may greatly modify the spectral energy distribution of the light source. Heat-absorbing glasses should be Pittsburgh 2043, 2 mm thick or an equivalent filter. Adjustments of intensity are made by neutral density filters or diaphragms or both, depending on the particular printer. The final adjustment of color quality is made with Kodak Color Compensating Filters, but

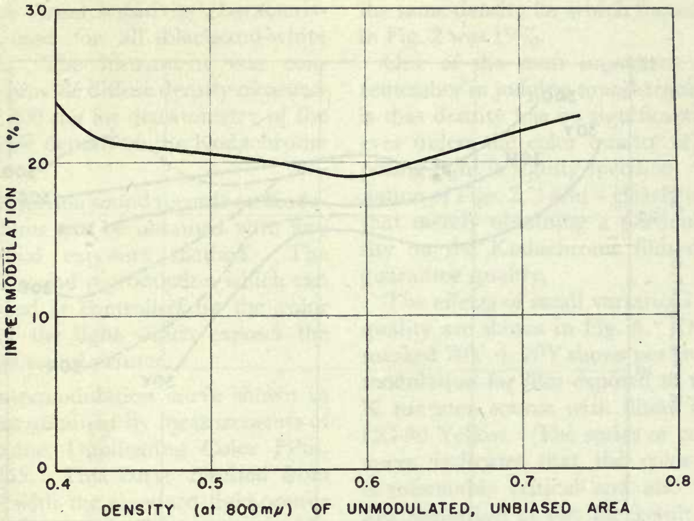


Fig. 2. Intermodulation. Unfiltered light of 2900 K tungsten source.

these filters are not part of the standard source.

Kodak Color Compensating Filters are gelatin filters and should be protected from heat as much as possible. Heat-absorbing glasses should be between the light source and the filters and physically separated as much as possible. Additional air-cooling of the filters is desirable and may be absolutely required in some printers.

The color compensating filters are a necessary part of the filter pack for printing sound on Kodachrome films. The capabilities of printed Kodachrome film for sound reproduction are much better than previous investigators[1,2] have reported, primarily because so little attention was paid to the color quality of the light used in exposing the sound track. The color quality must coordinate the speeds of the three layers or the best sound quality will not be obtained.

Determination of Exposure Conditions for Optimum Sound Quality

Distortion of variable-density prints was determined by the intermodulation method[3] using conditions prescribed by American Standard Z22.51. The negatives employed were sensitometrically normal negatives suitable for printing on black-and-white release positive film. A negative on Eastman Fine Grain Sound Recording Film, Type 5373 was exposed and processed for a gamma of 0.55 and density of 0.55. This negative was printed on Eastman Fine Grain Release Positive Film, Type 7302 and processed to a density of 0.55 and gamma of 2.50.

Variable-area distortion was determined by the cross-modulation test[4] with conditions prescribed by American Standard Z22.52. This standard designates a 4000-cycle carrier frequency amplitude-modulated at 400 cycles/sec. The negatives used were prepared on Eastman Fine Grain Sound Recording Film, Type 5372, with a gamma of 3.65 and total diffuse visual density of 2.98. The negatives were printed onto Eastman Fine Grain Release Positive Film, Type 7302 to a gamma of 2.48 and density of 2.0.

A Western Electric RA-1100B Densitometer was used for all density measure-

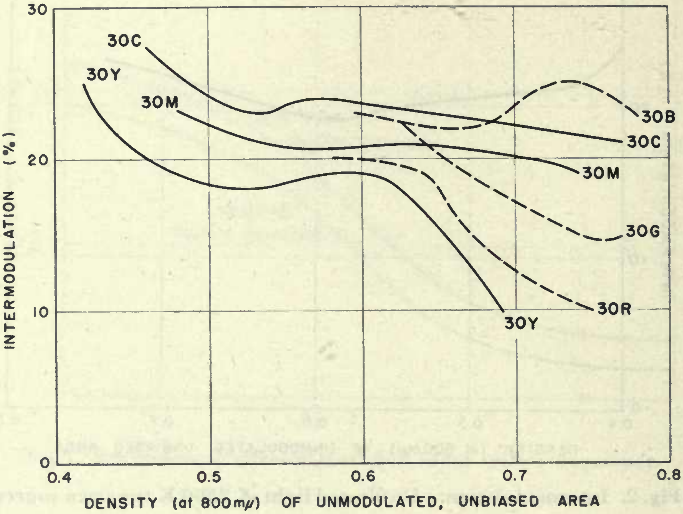


Fig. 3. Intermodulation. Filtered light of 2900 K tungsten source.

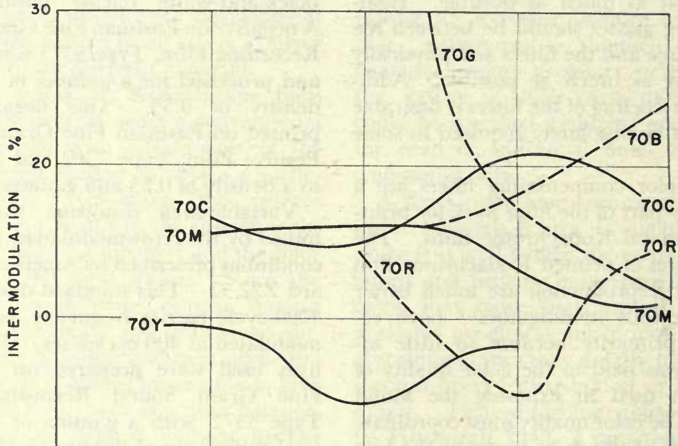


Fig. 4. Intermodulation. Filtered light of 2900 K tungsten source using stronger filters in the printing beam than shown in Fig. 3.

ments. A visual sensitivity characteristic was used for all black-and-white materials. The instrument was converted to provide diffuse density measurements at 800 mμ for densitometry of the silver sulfide deposit on the Kodachrome films.[5]

Low-distortion sound records on Kodachrome films can be obtained with any conventional exposure method. The quality of sound reproduction which can be obtained is controlled by the color quality of the light which exposes the film in the sound printer.

The intermodulation curve shown in Fig. 2 was obtained by measurements of Kodachrome Duplicating Color Film, Type 5265. This curve resulted from exposure with the standard light source previously mentioned but without additional color-compensating filters. The only variable in this exposure was the intensity of the printing light. A common error has been to assume, after obtaining such a curve, that this represents the best that could be expected from printed sound tracks on Kodachrome film.

The series of intermodulation curves in Fig. 3 were obtained from measurements of Kodachrome film which had been exposed to different color qualities of light. The curve marked 30Y shows per cent intermodulation for film exposed to the standard 2900 K source with a CC-30 Yellow filter in the printing beam. Intensity changes were made with carbon-deposit, neutral-density filters.

The intermodulation curves shown in Fig. 4 were obtained from measurements of film which had been exposed using stronger filters in the printing beam. The curve obtained by printing with the standard source plus Kodak Color Compensating Filters equal to CC-70 Yellow resulted in an intermodulation level of 4%. This low level of distortion was obtained at a density at 800 mμ of 0.6 (diffuse visual density of 1.4). This is the same density for which the minimum in Fig. 2 was 19%.

One of the most important facts to remember in judging sound-track quality is that density has no significance whatever unless the color quality of the exposing light is rigidly specified. Examination of Figs. 2, 3 and 4 clearly indicates that merely obtaining a particular density on the Kodachrome film does not guarantee quality.

The effects of small variations of color quality are shown in Fig. 5. The curve marked 70Y + 20Y shows per cent intermodulation for film exposed to the 2900 K tungsten source with filters equal to CC-90 Yellow. The series of color balances indicates that the color quality is reasonably critical and also that the low distortion is not the result of confinement of the image to any one layer.

The choice of an optimum balance for variable-area track is less obvious because the cross-modulation product is at least 40 db below the 400-cycle reference level for a considerable range of color balances. Additional considerations governing the choice of color balance for exposing variable-area records are volume level, signal-to-noise ratio, frequency response, and exposure latitude. The cross-modulation curves of Fig. 6 show that the best color balance for variable density, obtained with a CC-70Y filter in the printing beam, is not the most desirable balance for the exposure of variable-area records. In this case the CC-30M balance provides low distortion with the highest usable volume level. Again, density alone is not an indication that the film has been properly exposed.

Conclusions

The color quality of the light which exposes the film in the sound-track printer controls the potential quality of sound reproduction which may be obtained from Kodachrome sound tracks. Density alone is not sufficient to guarantee that the color film has been properly

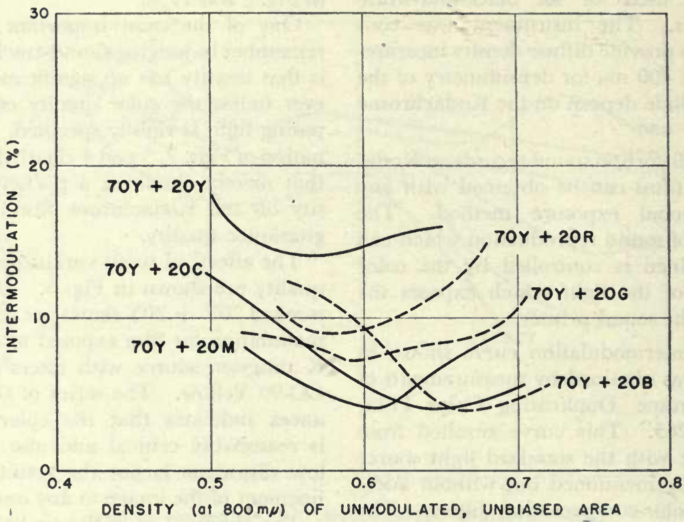


Fig. 5. Intermodulation. Effects of small filter changes from optimum variable-density balance.

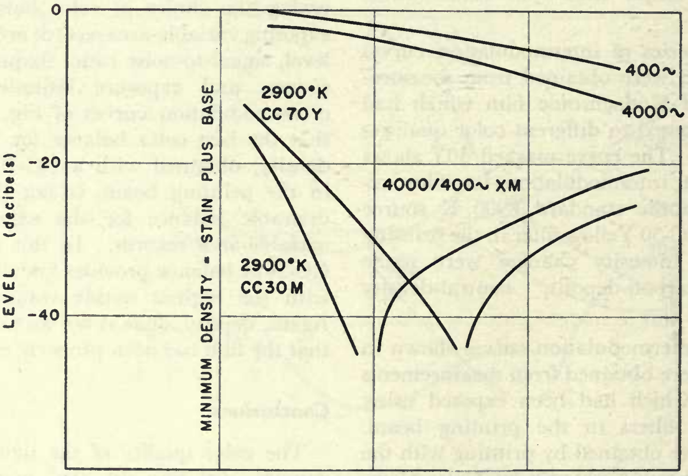


Fig. 6. Cross modulation. Comparison of best variable-area balance with best variable-density balance.

exposed. Density is only significant when the color quality of the exposing light is rigidly specified.

References

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2. John G. Frayne, "Electrical printing," *Jour. SMPTE, 55:* 590–604, Dec. 1950.
3. John G. Frayne and R. R. Scoville, "Analysis and measurement of distortion in variable-density recording," *Jour. SMPE, 32:* 648–673, June 1939.
4. J. O. Baker and D. H. Robinson, "Modulated high-frequency recording as a means of determining conditions for optimal processing," *Jour. SMPE, 30:* 3–17, Jan. 1938.
5. R. C. Lovick, "Densitometry of silver sulfide sound tracks," *Jour. SMPTE, 59:* 89–93, Aug. 1952.

Discussion

Anon: I'd like to ask the color temperature and the type of photocell used in the playback on all of your test curves?

Mr. Lovick: The color temperature of the lamp used in the reproducer was 2800 K. It does make a difference. We use an unfiltered Type 868 phototube.

Anon: It's a cesium cell?

Mr. Lovick: It's a cesium surface with an S-1 response.

H. R. Kossman (*Cameraflex Corp.*): I would like to know a little more about the filter for the sound printer. Is it a glass filter you propose to use there?

Mr. Lovick: No, we're proposing to use the Kodak Color Compensating Filters. They are gelatin filters. You have to cool these filters if they're tightly enclosed in some printers, particularly in contact printers. You don't have too much trouble in printers such as the Bell & Howell Model J.

Mr. Kossman: You know, we have rather confined space there. Of course, they have a blower system. . . .

Mr. Lovick: I realize that in many printers there is quite a confined space. However, you cannot get good sound reproduction unless you make some provision for using filters of this type to adjust the printer light to the color quality that will give you the best results.

Mr. Kossman: I notice that some of the labs are using an ultraviolet filter.

Mr. Lovick: The ultraviolet filter gives poorer results than you can expect from the color-compensating type of filter. It also takes considerably more light.

F. P. Herrnfeld (*Herrnfeld Engineering*): You mentioned a 2-mm heat-absorbing glass. Which one do you use?

Mr. Lovick: We use the Pittsburgh 2043.

Mr. Herrnfeld: Have you investigated single-layer exposures?

Mr. Lovick: Yes, single-layer and double-layer exposures. It's necessary to use preflash techniques in order to avoid unmodulated silver sulfide density in the other layers. There's some improvement possible for variable-density records particularly in the exposure latitude. We don't lower the minimum distortion but gain in latitude by using a Wratten No. 29 filter to preflash the bottom layer. There's no particular value in trying to remove the middle layer of the film. You get improved latitude at the expense of the signal-to-noise ratio.

George Lewin (*Signal Corps Photographic Center*): Will you tell us how this new Kodachrome is going to be distinguished from the present type?

Mr. Lovick: I believe the last of the old Kodachrome emulsion is 5265-953. The new films are number 1 or later.

Mr. Lewin: It will not be necessary to order it specially?

Mr. Lovick: No.

Mr. Lewin: As time progresses, we'll start getting the new type?

Mr. Lovick: The new type will be supplied as rapidly as possible.

Mr. Herrnfeld: In your test, how do these filters compare with the emulsion pack you use for picture printing?

Mr. Lovick: The filter pack for picture printing is a composite pack consisting of some cyan, magenta and yellow filters. I believe basically it's about 30 cyan, 30 magenta and 10 yellow. That's based again on the 2900 K source that's recommended for Kodachrome picture printing.

Mr. Herrnfeld: Have tests been made using the picture printing filter pack to print the sound track?

Mr. Lovick: The results are poorer than those obtained with a properly color-compensated sound exposure. The filter pack that is used for printing pictures is still almost a neutral pack, as far as that 2900 K source is concerned. There are simply enough additional filters available so that you can remove some to adjust the color quality.

Mr. Herrnfeld: What was the filter pack you mentioned? I mean approximately, is it minus the yellow? The reason I am asking is that I have made extensive tests on other products and I have found that if you get a good gray curve from your film, in other words that the three emulsions give you approximately the same gamma, that is where we had the best processing quality of sound films.

Mr. Lovick: That isn't necessarily true. Each emulsion was designed for a particular dye, irrespective of the amount of halides necessary to get that dye. If you convert those halides to silver sulfide instead of the dye, the curve shapes are no longer similar to what they were for the dye deposits. There's no reason to believe that they'd be similar. The speeds, too, might be quite different. Suppose that you have to have one and one-half times more halides available for the yellow layer than for the other layers in order to get sufficient yellow dye density. When converted to silver sulfide, you would have that much additional contrast in that particular layer.

Densitometry of Silver Sulfide Sound Tracks

By ROBERT C. LOVICK

Silver sulfide deposits have spectral density characteristics which tend to make densitometry less reliable than density measurements of silver deposits. Interference filters may be useful in restricting the bandwidth of response of electronic densitometers so that densitometry of silver sulfide deposits will have increased significance.

THE SOUND TRACK on Kodachrome film and other multilayer, reversal, color films is commonly a deposit of silver sulfide. Silver sulfide images are used because no satisfactory solution has yet been obtained to the problem of producing a good silver image in the sound track area and pictures free of silver in the adjacent area.

The curves of Fig. 1 show density as a function of wavelength for a silver deposit on 16mm Eastman Fine Grain Release Positive Film, Type 7302, and for a reversal silver sulfide deposit on Kodachrome Duplicating Color Film, Type 5265. Physical densitometers usually have maximum sensitivity in the visual region at about 525 mμ. In this wavelength region, the major errors in the measurement of the density of photographically deposited silver are the result of the geometry of the instrument. Differences in spectral response of the receptor have practically no effect on the calibration of the densitometer. The accuracy of density determination may be adequately stated for silver deposits. There is a tendency to assume that the same reliability applies to silver sulfide deposits.

The density of silver is minimum at 525 mμ and increases moderately with wavelength. The density of silver sulfide varies much more with wavelength. Assuming equal densities at a wavelength of 800 mμ, the slope of the spectral density curve for silver sulfide is over six times greater than the slope of the curve for a silver deposit.

The density of the silver deposit measured at 800 mμ is 14% greater than the density at 525 mμ. The density of the silver sulfide deposit measured at 800 mμ is only 40% of the density at 525 mμ. Consequently, silver sulfide sound tracks are visually denser than the density effective in a reproducer with a phototube having an S-1 response. As a result, reversal silver sulfide sound tracks are often seriously overexposed in attempts to give them the appearance of silver sound tracks.

Measurements of sound tracks to obtain indications of the density effective in a reproducer require that heat-

Presented on April 24, 1952, at the Society's Convention at Chicago, Ill., by Robert C. Lovick, Color Control Div., Eastman Kodak Co., Rochester 4, N.Y.

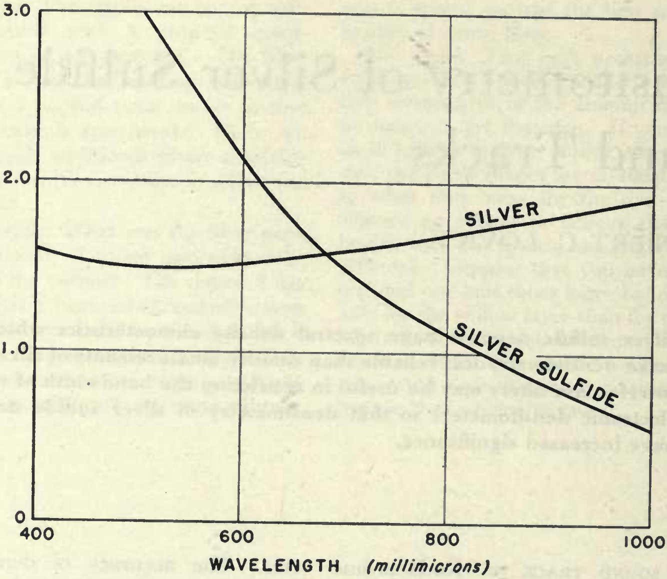

Fig. 1. Spectral density of silver deposits on Type 7302 and silver sulfide deposit on Type 5265.

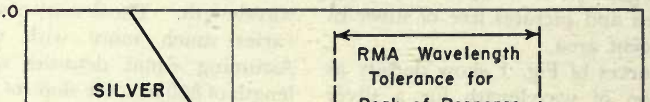

Fig. 2. Standard S-1 Phototube response.

absorbers and other filters be removed from the optics of the densitometer and that the S-4 phototube be replaced with a phototube having an S-1 response.

Wavelength Tolerances

A standard, equal energy response curve of a phototube with an S-1 response is shown in Fig. 2. The peak sensitivity of a standard tube occurs at 800 mμ. Such phototubes were not designed or ever intended for precise photometric measurements. As a consequence of their general purpose design, wavelength tolerance limits of ± 100 mμ have been established for the peak sensitivity. These limits are entirely satisfactory for their general purpose service but can produce large differences in the measured density of silver sulfide sound tracks.

For the spectrophotometric curve of silver sulfide shown and the maximum and minimum wavelength tolerances for peak sensitivity of the phototube, it has been computed that the measured density of the sample would be 0.68 and 1.3 respectively. The potential error due to wavelength tolerance alone for peak sensitivity of the phototube is $\pm 30\%$. On a practical basis, this error seems to be about $\pm 10\%$.

Color Temperature Effect

The output of the phototube is the product of the equal energy response and the relative energy of the light source at every wavelength. The curves of Fig. 3 show the product of the standard response and the energy of tungsten sources at 2500 K and 3000 K.[1] Of course, some densitometers may have light sources with higher or lower color temperatures than these, but this variation can introduce a significant error in the densitometry of silver sulfide deposits. If a standard S-1 phototube is placed in a densitometer and the color temperature of the light source is changed from 2500 K to 3000 K, the measured density of this sample will change from 0.90 to 1.02. This is a density discrepancy of $\pm 6\%$.

Variations in Spectral Sensitivity

Another cause of differences in measurements is the effect of different spectral sensitivity for tubes having peak sensitivities at the same wavelength. From a small group of tubes having peak sensitivity at the same wavelength, it appears that this potential error is of the order of ± 3 or 4%, possibly larger.

These sources of error are important because they are quite large and yet may be overlooked in the estimate of reliability of densitometry. The tendency is to assume that because measurements on a silver deposit in the visual region indicate an accuracy of 1 or 2%, that measurements on the silver sulfide deposit are of the same order of reliability.

Measurements With Densitometers Having Visual Response

Measurements of silver sulfide sound track densities by densitometers with phototubes having an S-4 response or by visual instruments are much more affected by the variation of density with wavelength than are measurements with instruments having phototubes with S-1 response. Density measurements, in the visual region, of the silver sulfide deposits are more sensitive in detecting density variations than are measurements at 800 mμ, but they are considerably less precise. In addition, sound tracks on Kodachrome films have some unwanted magenta dye present which, although virtually unseen by the usual reproducer phototube, will contribute significantly to the visual density measurement. Visual density measurements may, therefore, show variations which in no way affect sound reproduction. The significance of visual measurements is further reduced by the possibility that as less silver sulfide is formed, more magenta dye will be formed, and although the visual density measure-

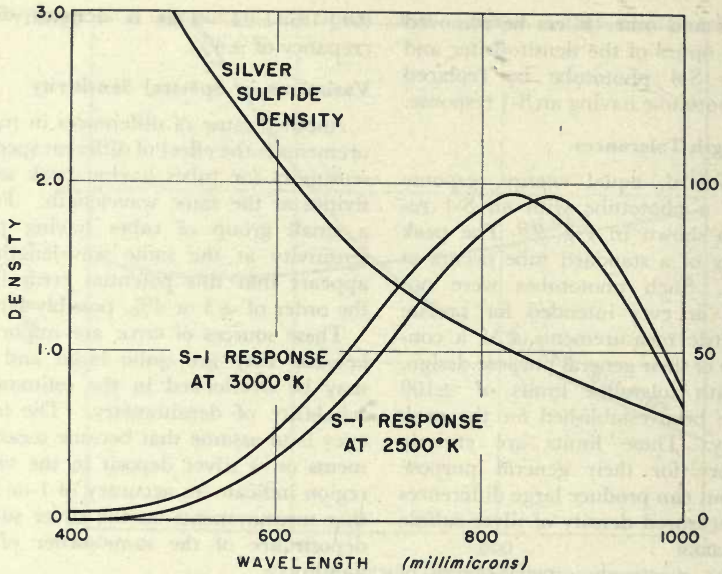

Fig. 3. Effect of tungsten light source color temperature change.

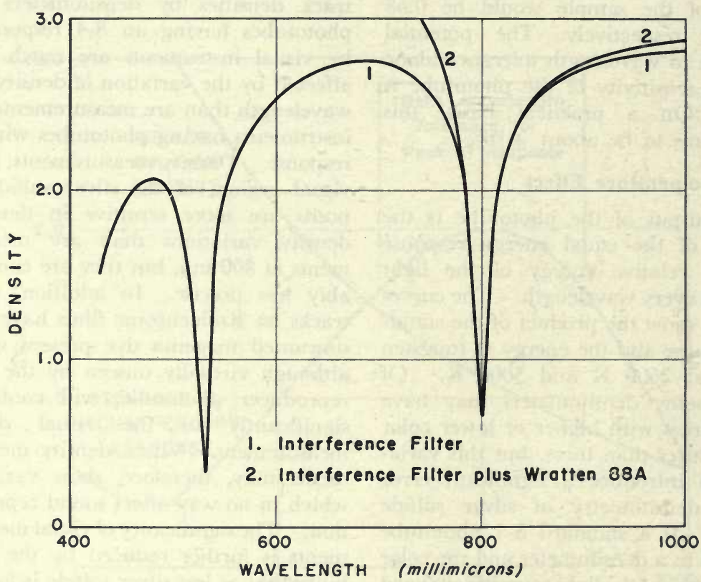

Fig. 4. Spectral density characteristic of one type of interference filter.

ment may be only slightly affected, the phototube of the usual sound reproducer will see a reduced image contrast with definite effect on the reproduction of sound.

Measurements of silver sulfide sound tracks by densitometers with phototubes having S-4 response or by visual instruments are to be discouraged.

Standardized Densitometry

The interchange of useful information on sound track printing conditions would be greatly facilitated by standardized densitometry. The method most likely to produce an acceptable degree of correlation requires the use of an interference filter[2,3] to restrict the response of the densitometer to a bandwidth of a few millimicrons. The density characteristics of one type of interference filter are shown in Fig. 4. With such a filter, the effects of variations of the wavelength of peak sensitivity, shift of peak due to color temperature of the light source, the effects of aging, and differences in spectral sensitivity of phototubes are virtually eliminated. In fact, practically the only sources of error that remain are due either to the geometry of the instrument or to error in the determination of the wavelength of peak transmission of the filter.

The effects of tube responses are eliminated so that the same density is indicated whether an S-1 or S-4 response is used. Of course, the sensitivity with an S-4 response is so much less that it would seldom, if ever, be used.

The filters are relatively dense so that as much as two density ranges may be lost. This restricts the choice of wavelengths for standardized densitometry. If 550 mμ were chosen, the required unfiltered range for the densitometry of a sound track on Kodachrome film would be 0 to 6, since it would be necessary to be able to read to a density of about 3.2. However, at 800 mμ the unfiltered density range required would be only a little more than 3, since the maximum density at 800 mμ of the reversal silver sulfide sound track on Kodachrome film is now under 1.0.

Acknowledgment

The author wishes to acknowledge the contribution of Jack Pinney and Edward Letzer of the Color Control Division in obtaining materials and data for study of the problems of densitometry of silver and silver sulfide deposits.

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Discussion

John G. Frayne (*Westrex Corp.*): I'd like to ask if those figures given for density are diffuse density?

Mr. Lovick: They're diffuse. These densities are measured on the Western Electric RA - 1100B Densitometer modified for this purpose.

Dr. Frayne: With the interference filter in the optical system, what density are you able to measure with the existing amplifier?

Mr. Lovick: We have modified the amplifier so that even with the additional filter we still get a density range of 4.

Dr. Frayne: Is that information going to be available? We'd like to know about it.

Mr. Lovick: You mean how to modify the amplifier?

Dr. Frayne: Yes.

Mr. Lovick: It's only necessary to change a few resistors in the preamplifier.

Dr. Frayne: Even that's worth knowing. Are the interference filters available?

Mr. Lovick: Yes. We've obtained some from Bausch & Lomb. The tolerance which I think we should require is about plus or minus 2 millimicrons in order to get good correlation.

Modulated Air Blast for Reducing Film Buckle

By WILLY BORBERG

Present-day demands for high-intensity light sources point up the need for a suitable technique for reduction of excessive film buckle. Air jets which direct a continuous air flow against one or both of the film faces have been proposed. This technique does not, however, take into account the cyclical nature of film surface deformations during projection. It is found that improved performance can be obtained with a modulated air blast which is synchronized to the frame cycle. This paper describes the cyclical effects involved and shows why the modulated air blast is to be preferred over continuous air blast. It presents experimental data regarding buckle magnitudes in 35mm film and describes the experimental equipment.

THE TYPE OF BUCKLE with which we are concerned in the present discussion is a deformation which takes place during the frame cycle while the film is in the aperture. It may leave no record of its existence on the film after projection. It can be made visible by stroboscopic or high-speed photographic techniques, appearing as a rythmic — almost breathing — motion of the film surface in the aperture. It produces deterioration of image focus during part of the rapidly recurring projection cycle.

The causes of film buckle have been investigated and described before. Carver, Talbot and Loomis,[1,2] as well as Kolb,[3] have done considerable work on the subject in connection with broad studies of film performance. They have developed the terminology needed for presentation and their usage will be followed. The present discussion will be concerned with those effects which vary during the film frame cycle. However, a brief statement of the basic factors will not be amiss.

Each single picture frame goes through a cycle which starts with pulldown into the aperture, proceeds through the first exposure, the flicker blade cutoff and the second exposure, and ends with the pulldown of the next frame. During the two exposure intervals the film arrests some of the radiant energy from the light source and transforms it into heat. This causes the film to buckle (or bulge) in a manner very similar to that observed in the operation of a bimetallic element.

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The emulsion, being more opaque than the base, absorbs energy, expands and becomes the outer or convex surface of the bulge. The magnitude of the deformation produced varies continuously during the frame cycle and by an amount which is more than sufficient to affect sharpness of image focus.

The emulsion side of 35mm film is toward the light source; and hence the film tends to move toward the light, away from the lens, while it is in the aperture.

In accordance with the accepted terminology, the deformation is called *negative* when the emulsion side is convex, and conversely, *positive* when the emulsion side is concave. Flat film is considered to have *zero* deformation.

The film upon entering the projector gate is not necessarily flat, but may have a slightly positive curl, the magnitude of which depends to some extent on the age and condition of the film. It appears that there is some shrinkage of both emulsion and base, the emulsion shrinking more than the base, so that the resulting curl is slightly positive. Typical positive displacement at the center of cold 35mm film as it enters the gate is between zero and 0.010 in.

Instantly upon registration of the film frame with the aperture, the shutter uncovers the light for the first exposure of the cycle. Light energy is absorbed in the emulsion and transformed into heat. The expanding emulsion causes the exposed portion of the film frame to move from its initial zero or positive position, shifting it to a negative position, and causing it to take a somewhat spherical shape. There is a constantly increasing deformation during the first exposure, and a constantly changing distance of the emulsion surface with respect to the lens. Upon interception of the light by the flicker blade, further movement of the film surface toward the light source comes to a halt. With no light on the film, heat absorption by the film cannot take place. Instead, there is a loss of heat which causes the film to recede slightly toward the zero plane. At the start of the second exposure, the film surface stands somewhere between zero and its former maximum negative position. During the second exposure, the film continues its excursion negatively, first rapidly, then leveling off. At the end of this exposure the film reaches a more negative position than at the end of the first exposure.

Figure 1 shows the correlation between the movement at the center of the film surface and particular instants in the frame cycle. The same movement occurs at points off the center of the film surface, though to a smaller degree. A significant effect which may be noted is that the center of the film, which is in motion during the entire cycle, travels through and beyond the acceptable focus limits defined by the depth of the focus of the projection lens.

The projectionist, whose eye just cannot follow this rapid sequence of events (48 times per second), has to pick a "best average focus" position of the projection lens, somewhere between the maximum positive and maximum negative of the two exposure periods. If he judges the focus at the center of the screen, he picks a "best average focus" position near the maximum negative buckle of the first exposure. The remaining, earlier part of this exposure produces only a poor and undefined image on the screen. A portion of the second exposure, also, is beyond the limit of good image definition on the screen, and good optical performance can take place only during that part of the exposure in which the film displacement line lies within the depth-of-focus range. The "best average focus" thus obtained gives the best attainable image at the center of the screen. Actually, in practice, the projectionist may choose a slightly less negative lens position, which is a compromise to gain relatively fair overall definition across the whole screen. Even this compromise results in a fairly large percentage of "out-of-focus" time during a cycle.

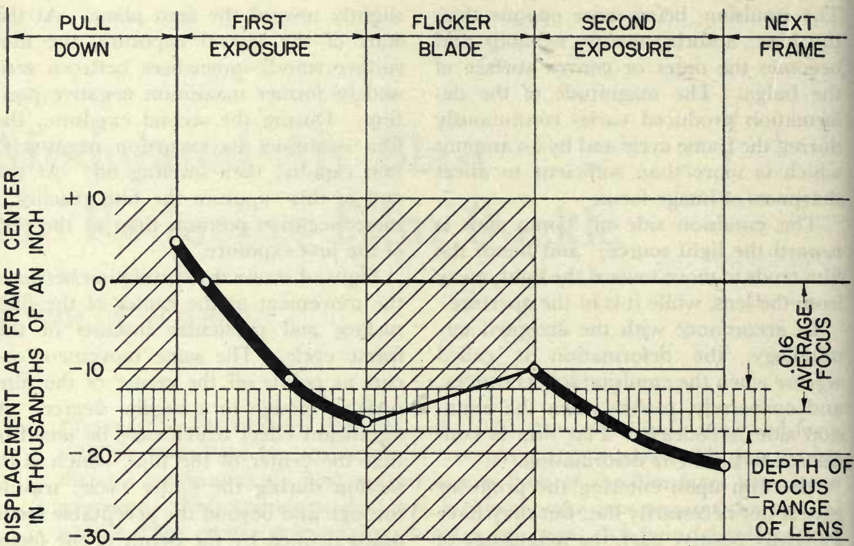

Fig. 1. Film displacement due to buckling at center of frame—No Air.

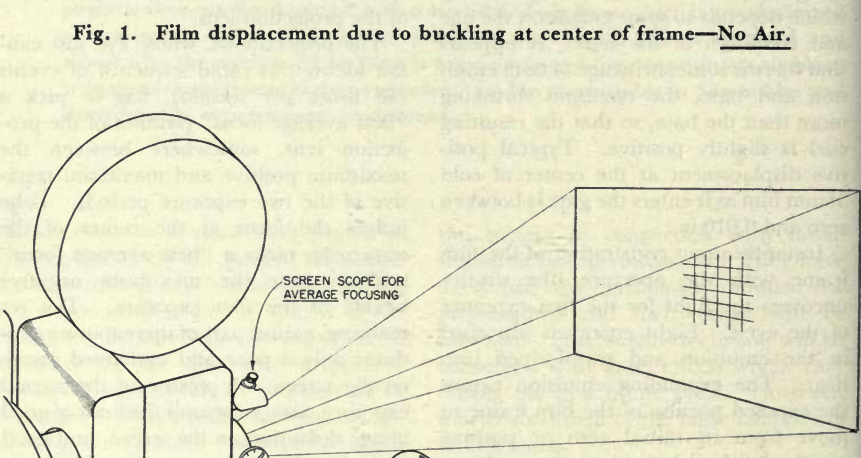

Fig. 2. Test equipment used to determine film buckle magnitudes and time relations.

For the conditions demonstrated in Fig. 1, good optical performance is attained during only about 40% of the first exposure and 60% of the second exposure, or a total of only 50% during a complete frame cycle. This is the best the projectionist can do.

The figures so far presented demonstrate the magnitude of the defect with which we are concerned, since they have been obtained with representative equipment, operating under conditions which might be found in any large theater. For test purposes, the projector was fitted with facilities to determine the various focus positions of the 5-in. focal length $f/1.9$ projection lens.

The light source was a Hi-Candescent Arc Lamp, with F-2 condensers, burning at 160 amp and delivering about 9000 lm to the screen with the shutter running.

All focus settings were made with the aid of Simplex Screen Scopes. The 8-power magnification thus provided enabled lens adjustment with greater precision than could have been attained by direct observation of the screen from the projector.

The film plane position along the optical axis was measured directly in terms of lens displacement, a dial indicator calibrated in thousandths of an inch being affixed to the lens mount for this purpose. Initial calibration for zero position on the dial indicator was made by focusing the lens to produce a critically sharp image of a conical hole in a flat steel plate, the small end of the hole being in the same plane as the emulsion contacting surfaces of the film trap. Up to this point, the method and equipment are essentially the same as those employed and described by Kolb.[3]

The addition of a viewing shutter to the equipment enabled observation of successive phases of the cyclicly varying film frame motion (see Fig. 2). The viewing shutter's drive-motor stator was rotatable so that the shutter opening of about 9° could be phased with relation to the synchronously running projector. This stroboscopic arrangement made it possible to view the screen image in small time increments of about 1 msec through all exposure phases of successive frame cycles. The film emulsion position during any specific phase of the exposure periods could thus be established without regard to possible out-of-focus conditions during the remaining unobserved portions of the cycle. Dial indicator readings were then recorded in relation to the phase settings. A contactor on the projector shutter timed a short-duration light flash for establishing correct phase reference.

The equipment as described permitted studies of film behavior under actual operating conditions.

The technique of air-blast cooling of film, by which opposing air forces of the front and rear jets are adjusted so as to produce a force for positioning the film, was found to be at best a partial solution to the problem. It is possible to move the film by this method and to shift the average focus position; the resultant force, however, acts upon the film continuously, and therefore, cannot correct for the intermittent cyclical frame deformations caused by the internal buckling forces in the film which occur during the two exposure periods.

The center of each frame travels over a range of about 0.020 or 0.030 in. This range is not greatly reduced by application of a continuous displacing air force (Fig. 3). The continuous jets produce a shift in average focus position; this, by itself, only slightly alters the ratio of "in focus" and "out-of-focus" intervals. The air serves primarily as a cooling agent, preventing possible damage to the film in the form of embossing or blistering or the formation of permanent buckle.

It was felt that, because of the cyclical nature of the film frame deformations involved, any corrective action to neutralize the defects should be similarly cyclical. Hence, the following approach (Figure 4) was tried:

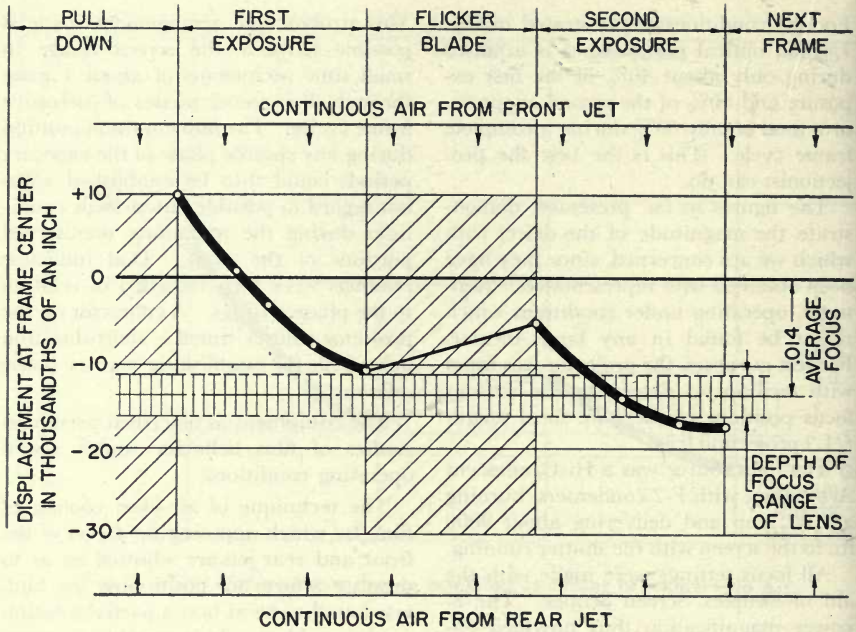

Fig. 3. Film displacement due to buckling at center of frame—Continuous Air.

(a) The air from the front jet was modulated by means of a rotary valve driven from the shutter shaft.

(b) The air from the rear jet was not modulated and the steady stream of air from this jet was used to force the film toward the lens, thus partly neutralizing the internal forces, which tend to make the film take a deep negative buckle under the influence of light.

(c) The correcting air pulses from the joint jet were timed so that the resultant forces from both front and rear jets opposed the cyclicly varying buckle forces. The motion of each film frame on the optical axis could thus be controlled.

Figure 5 illustrates the timing of the jets and shows that the position of the film frame can be held steady within fairly close limits. It should be noted that the excursions of the film frame surface can be confined to the depth-of-focus range of the lens. Good optical performance is thus attained over virtually the entire frame cycle.

Figure 5 also shows that a negative displacement of approximately 0.012 in. is allowed to exist at the center of the frame. The question may be asked, "Why is the process not carried beyond this point so as to bring the displacement to zero?" There are two reasons for not doing so. The first, as pointed out by Kolb, is concerned with the performance of the projection lens. In most projection lenses the focal plane of field is not truly a plane, but rather a curved surface. For best performance in this respect, the film is allowed to approximate this surface. The second reason is that flat film seems to be somewhat flaccid under the influence of air flow, as compared to film which is bowed to even a slight degree.

Since the film can be kept within the depth-of-focus limit of the projection lens during nearly the entire time of the two

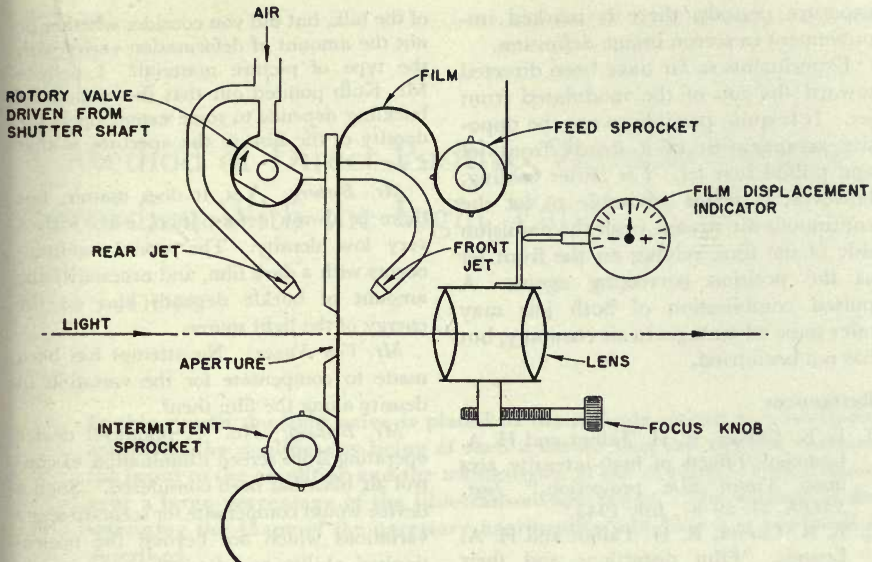

Fig. 4. Arrangement of air jets and film displacement indicator.

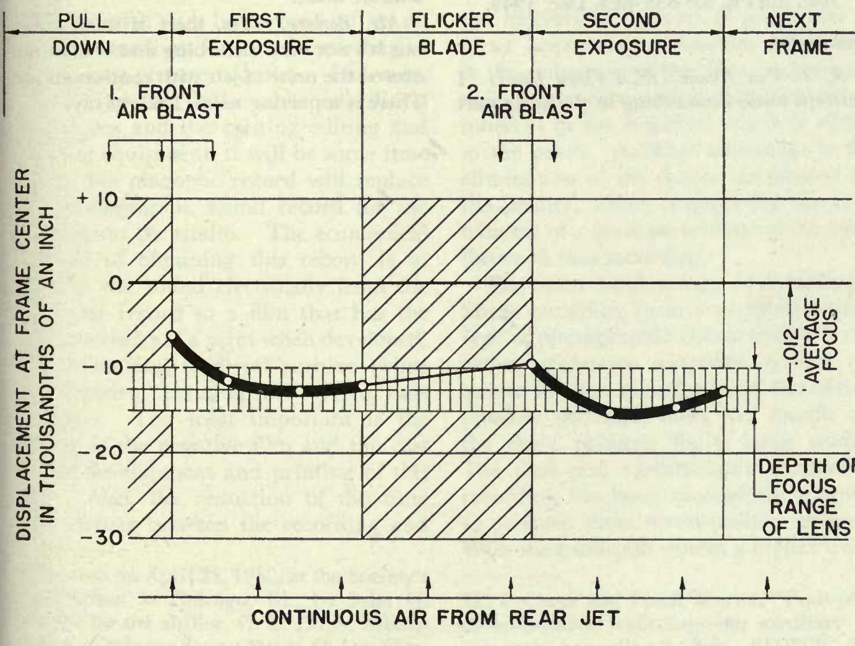

Fig. 5. Film displacement due to buckling at center of frame—Pulsed Air.

exposure periods, there is marked improvement in screen image definition.

Experiments so far have been directed toward the use of the modulated front jet. It is quite possible to use the opposite arrangement of a steady front jet and pulsed rear jet. For better cooling, however, it seems advisable to let the continuous air stream wash the emulsion side of the film, relying on the front jet as the position correcting agent. A pulsed combination of both jets may offer some advantages in air economy, but has not been tried.

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Discussion

R. T. Van Niman (RCA Victor Div.): I perhaps missed something in the early part of the talk, but did you consider whether or not the amount of deformation varies with the type of picture material? I believe Mr. Kolb pointed out that the amount of buckling depends to some extent upon the density of the film in the aperture at that time.

Mr. Borberg: Yes, it does matter, but there is always deformation, even with a very low density. The worst condition occurs with a dark film, and necessarily the amount of buckle depends also on the energy of the light source.

Mr. Van Niman: No attempt has been made to compensate for the variation in density along the film then?

Mr. Borberg: No. A photocell device operating from screen illumination to control air blast has been considered. Such a device would compensate for scene-to-scene variations which are beyond the projectionists' ability to follow, but the instrumentation just hasn't gone that far.

W. W. Lozier (National Carbon Co.): Does the intermittent air blast make much audible noise?

Mr. Borberg: Yes, there is some noise, but it's not very disturbing and it does not exceed the noise of jets with continuous air. There is a purring noise, I might say.

A Method of Direct-Positive Variable-Density Recording With the Light Valve

By O. L. DUPY

In this system the light valve is placed in the cathode circuit of a nonlinear amplifier, the nonlinearity being of such a nature that the relation between the input to the amplifier and the transmission of the developed film is linear over a large percentage of the film-transmission range. The method of determining the shape of the necessary nonlinearity and how it is produced is described.

MAGNETIC FILM has proved to be an excellent medium for sound recording in the motion picture industry. However, considering the well-established editing techniques and the existing editing and viewing equipment, it will be some time before the magnetic record will replace the photographic sound record for use throughout the studio. The economical method of obtaining this record is to transfer the sound electrically from the magnetic record to a film that has the characteristics of a print when developed.

The making of direct-positive prints by electrical printing has several advantages. The most important is the saving of the negative film and the cost of the development and printing of this film. Also, the reduction of the time that elapses between the recording and the delivery of a print is sometimes of great importance. Another advantage is the reduction of the film background noise by the elimination of the film noise, inherent in the negative, which is added to the print. Another advantage is the elimination of the flutter introduced by the printer, which is generally the contributor of a good percentage of the total flutter in film recording.

The main disadvantage in obtaining a linear recording from a variable-density type of photographic characteristic is the rather elaborate amplifier system required to offset this distortion, but one or possibly two such units will handle all the daily printing for a large studio. The push-pull variable-area method of recording has been successfully adapted to produce these direct-positive prints.* With the push-pull system a higher track

Presented on April 25, 1952, at the Society's Convention at Chicago, Ill., by John G. Frayne for the author, O. L. Dupy, Metro-Goldwyn-Mayer Sound Dept., Culver City, Calif.

*L. I. Carey and Frank Moran, "Push-pull direct-positive recording—an auxiliary to magnetic recording," *Jour. SMPTE*, *58:* 67–70, Jan. 1952.

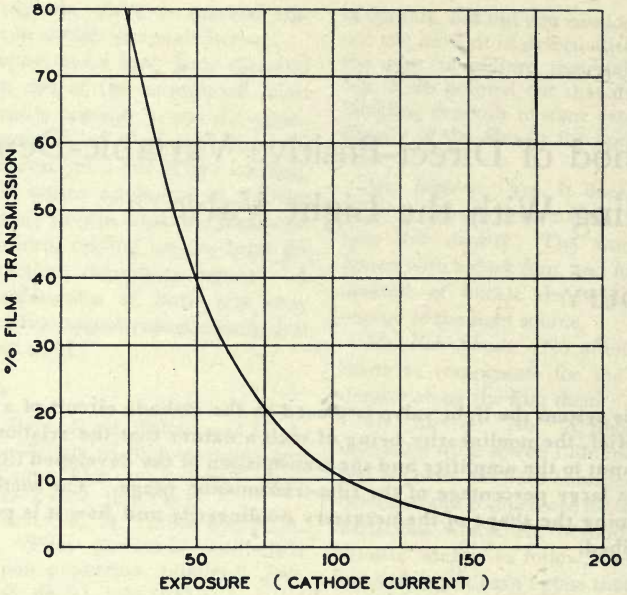

Fig. 1. Film-recording characteristic.

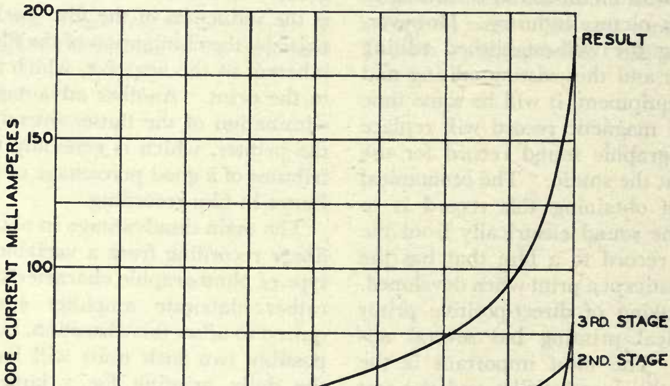

Fig. 2. Correcting nonlinear amplifier characteristic.

density than normal can be employed because of the cancellation of the cross-modulation products in push-pull reproduction, thus producing results that equal the cancellation achieved by the normal negative and print process. The nonlinear exposure versus light-transmission characteristics of the film enters into the problem of making a variable-density direct-positive. In order to determine the nonlinear characteristics, samples were exposed by sending direct current in fixed steps through the light valve in a standard recording machine. These strips were processed using the M-G-M standard release development procedure. The resulting strips were measured by inserting a 400-cycle chopper in the light beam of a standard film-reproducing machine and measuring the audio signal at the output of the photoelectric cell amplifier. By this procedure, the test included all the variables encountered in the recording and reproducing systems.

The resulting characteristic is shown in Fig. 1. The above tests were repeated over a period of time in order to check the stability of the variables involved. The results proved that this method of making a variable-density direct-positive was practical.

Figure 2 shows the schematic of an amplifier, the characteristics of which are the reciprocal of Fig. 1. The first stage of the amplifier has a practically linear characteristic and is used as a voltage amplifier directly coupled to the second and third stages or sections. The noise-reduction control voltage is fed to the input grid in series with the secondary winding of the input transformer. The second stage controls the shaping of the middle and upper end of the curve by being biased negative almost to cutoff; the signal received from the cathode resistance of the first stage is such that it is linear for the lower half of the range, and becomes nonlinear as the driving signal increases. The third stage controls the shaping of the extreme upper end of the curve. This is accomplished by biasing the grids negative beyond cutoff and driving them with a signal voltage that will cause the tubes to conduct only on the positive peaks of the signal.

Figure 3 shows the method of obtaining this curvature by using a number of tubes in parallel, the grids of which are biased to operate at various points in the nonlinear portion of their grid volts versus plate-current curves. The overall shape is obtained by adjusting the balance between the grid and signal voltage, and the number of tubes used.

The light valve must be directly coupled to this amplifier because the resulting distorted signal is composed of direct current; the signal fundamental and a large amount of harmonics of the signal, and in addition the noise-reduction signal must be altered by this circuit.

Figure 3 shows the contributions of all three stages and the overall characteristic of the nonlinear amplifier. A Western Electric RA-1238, 200-mil push-pull variable-density light valve was used in these studies and in recording the demonstration film which was run at the close of the paper. It is necessary to employ one amplifier of the type shown in Fig. 2 for each component of the push-pull valve. This results in a classical type of push-pull reproduction, and a higher degree of an overall linearity is obtained than when using a standard single track. However, good quality is obtained from a single track provided care is taken in the setting of the operating parameters.

A direct current is applied to the light valve, in opposition to the cathode current, for adjusting the static opening of the valve for zero signal input. A noise-reduction bias current is applied to each component of the light valve through its associated amplifier. Since the resulting sound track is in effect a positive, the ribbons are either mechanically or electrically biased open, rather than closed as in a normal negative-positive recording. The action of the input noise-

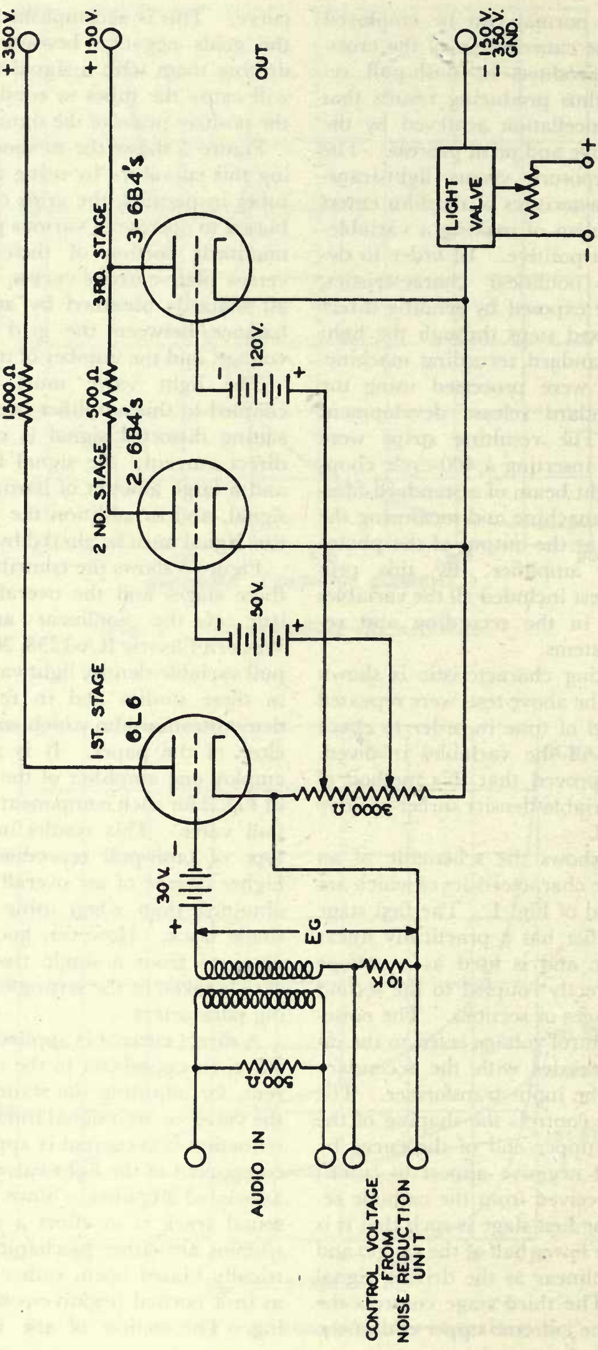

Fig. 3. Nonlinear amplifier schematic.

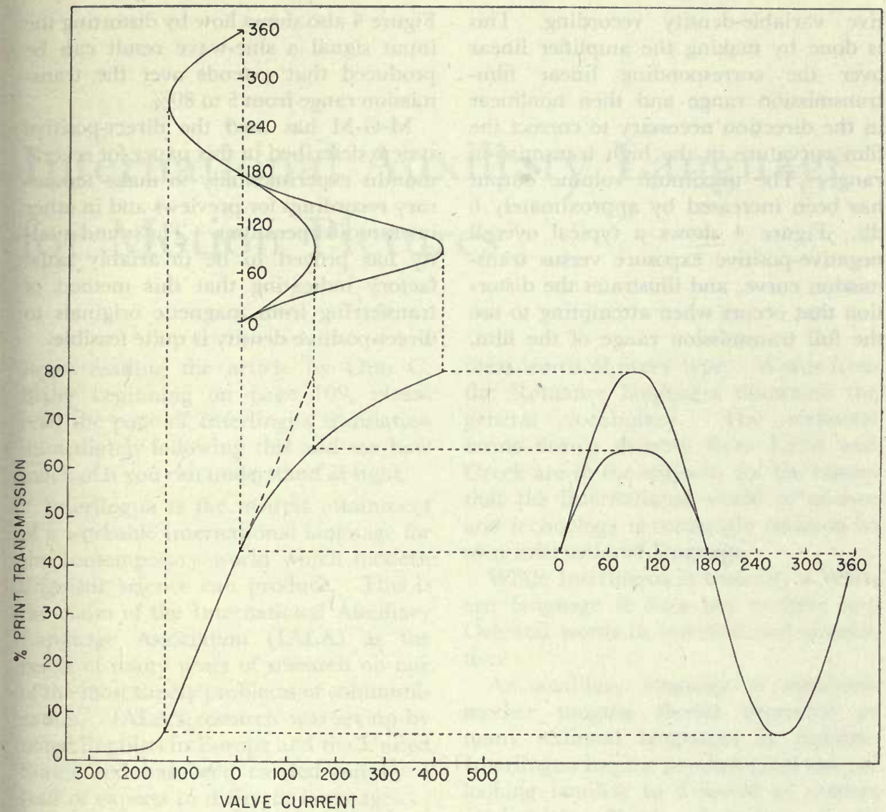

Fig. 4. Predistortion curve for extended range recording.

reduction voltage then serves to cancel this d-c bias, the minimum spacing of the ribbon being obtained for maximum signal input. Experience has shown that noise reduction equivalent to that obtained in ordinary recording can be obtained in this method of recording.

The shape of the correcting curve was checked by recording signals at various levels and measuring the distortion. The part of the curve that was incorrect was found by measuring the distortion of a low-level signal that was moved in steps, over the complete range of the characteristic, by independently varying the noise-reduction control voltage. This information was used for final individual adjustment of each section of the amplifier.

It should be noted that the current required from the B supply varies at both the signal envelope and audiofrequency rates. A regulated B voltage supply having a rapid recovery rate and a low internal impedance of about 0.9 ohms was satisfactory. The necessary maintenance, checking and adjustments have been reduced to a routine. We anticipate that experience will produce a system with better uniformity and quality than the negative and positive system.

Having developed a nonlinear system with adjustable characteristics, we have adapted it to extend the volume range of the print made from a standard nega-

tive variable-density recording. This is done by making the amplifier linear over the corresponding linear film-transmission range and then nonlinear in the direction necessary to correct the film curvature in the high transmission range. The maximum volume output has been increased by approximately 6 db. Figure 4 shows a typical overall negative-positive exposure versus transmission curve, and illustrates the distortion that occurs when attempting to use the full transmission range of the film. Figure 4 also shows how by distorting the input signal a sine-wave result can be produced that extends over the transmission range from 5 to 80%.

M-G-M has used the direct-positive system described in this paper for several months experimentally to make temporary recordings for previews and in other intrastudio operations. The sound quality has proved to be invariably satisfactory indicating that this method of transferring from magnetic originals to direct-positive density is quite feasible.

International Auxiliary Language for Motion Pictures

Before reading the article by Otto C. Bixler beginning on page 109, please read the page of Interlingua translation immediately following this and see how much of it you can understand at sight.

Interlingua is the nearest attainment of a workable international language for the contemporary world which modern linguistic science can produce. This is the claim of the International Auxiliary Language Association (IALA) as the result of many years of research on one of the most timely problems of communication. IALA's research was set up by noted linguists in Europe and the United States and has been carried out by a staff of experts in different languages.

IALA's staff has devised a system for screening off words which are internationally known and for giving them standardized forms and definitions. Some 27,000 of them are presented in the *Interlingua-English Dictionary.* A simple grammar employing only those features which languages have in common has been prepared to operate this *natural* international vocabulary.

Interlingua includes general and technical words of every type. Words from the Romance languages dominate the general vocabulary. The technical terms drawn directly from Latin and Greek are in the majority for the reason that the international world of science and technology is constantly creating its own international language.

While Interlingua is basically a Western language it does not exclude any Oriental words in international circulation.

An auxiliary language *to supplement* mother tongues should represent as many national languages as possible. Interlingua has the psychological asset of looking familiar to a world of readers comprising North America, South America, Europe, and readers in Asia and Africa who know one of the European languages.

IALA is bringing Interlingua to the attention of groups of scientists and technologists. The Association will welcome suggestions and comments from readers of the *Journal of the SMPTE* as to possible collaboration with engineering groups at the heart of the motion picture industry. The eventual use of Interlingua in export-film captions is not beyond practical imagination in the development of world markets.

Alfred N. Goldsmith, Past-President of the SMPTE, has been a member of the Board of Directors of IALA since its founding. The headquarters of IALA are at 420 Lexington Ave., New York 17, N.Y.

This presentation has been prepared through the kindly offices of Dr. Alfred N. Goldsmith. This brief description of Interlingua has been prepared by Mary Bray, and Dr. Alexander Gode has translated into Interlingua the page immediately following. Both are staff members of the International Auxiliary Language Association.

Un commercial phonoregistrator binaural

Per OTTO C. BIXLER

Le disveloppamento hodierne del apparatura de phonoreproduction es multo avantiate. Proque le avantages del registration stereophonic ha previemente essite demonstrate, nos ha credite que le proxime desiderato re apparaturas commercial esserea le fabrication a precio rationabile de un systema binaural. Nos presenta hic un revista del factores theoric implicite in binaural phonoregistration e reproduction, insimul con un description del apparatura technic disveloppate pro satisfacer le requirimento de alte qualitate acustic intra le limites de rationabile costos total. Nos describe alicun nove problemas e effectos incontrate in iste programma de disveloppamento.

Desideratos structural del apparatura binaural

Le decision a preparar pro uso commercial un binaural registrator a banda resultava del desiro de suppler phonoregistrantes con ameliorate e nove methodos de presentation. Esseva prendite in consideration le facto que usque nunc nulle binaural apparatura vermente commercial ha essite presentate al publico ben que numerose firmas (inter illos Bell Laboratories, Fox Studios, Warner Bros., e alteres) ha facite multo satisfactori demonstrationes stereophonic. Post le qualitate de phonoreproduction habeva essite avantiate a su presente alte fidelitate con excellente responsas a frequentia, minimal cambiamentos de phase e bon reproduction transiente, on recognosceva que alique, nonobstante, mancava. Iste "alique" es le distribution spatial del sono original. Le reproduction monaural del sono emanante de multiple fontes a disposition spatial introduce distortiones spatial. Le optime methodo a eliminar tal distortion es reproducer sonos stereophonicamente. Ver stereoreproduction de sonos es technicamente satis difficile e relativemente costose. Le secunde optime methodo es le binaural phonoregistration e reproduction. De facto, sonos binaural reproducite per medio de receptores auricular resulta pro le auditor in un quasi perfecte recreation del phonoimpacto original.

Presentate le 24 de april, 1952, al convention del Societate a Chicago, Ill., per Otto C. Bixler del firma Magnecord, Inc., 225 W. Ohio St., Chicago 10, Ill.

Theoria de audition binaural

In principio, le factores theoric del phonopresentation binaural visa a producer, a un plus tarde tempore, le mesme amplitude de sono e relation de phases in cata un del duo aures del auditor como si ille habeva essite originalmente presente. On debe notar que le aures e le cerebro del auditor constitue un systema de computation directional basate super lor sensitivitate a phases e amplitudes. Iste systema dual involve un area intersectional de "sensitivitate contra frequentia" que es determinate sequentemente:

A Commercial Binaural Recorder

By OTTO C. BIXLER

Present-day sound recording-reproducing equipment is at a very high state of development and, since the benefits of stereophonic recording have been previously demonstrated, it was believed that the next desirable step in commercial equipment would be the manufacture of a reasonably priced binaural system. A review of the theoretical factors involved in binaural sound recording and reproduction is presented along with a description of the technical equipment developed to fill the needs of high-quality binaural sound consistent with a reasonable overall equipment cost. Some novel problems and effects experienced in this development program are described.

Binaural Equipment Design Objective

The decision to design a commercial binaural tape recorder was based upon the desire to provide the recording field with an enhanced, novel method of sound presentation. Consideration was given to the fact that to date no true commercial binaural equipment had been presented to the public although many concerns, including Bell Laboratories, Fox Studios, Warner Bros., and others, have given highly satisfactory public demonstrations of stereophonic sound. After the quality of sound reproduction was brought to its present high fidelity with excellent frequency response, minimum phase shift and good transient reproduction, it was realized that something was still lacking. That something is the normal spatial distribution of original sound. Monaural reproduction of a spatially disposed multiple sound source introduces spatial distortion. The best way to eliminate this distortion is to reproduce sound in a stereophonic manner. True stereosound is quite difficult of technical achievement and is comparatively costly. The next best method is the use of binaurally recorded and reproduced sound. As a matter of fact, when binaural sound is reproduced through earphones an almost perfect re-creation of the original sound impact upon a listener is obtained.

Presented on April 24, 1952, at the Society's Convention at Chicago, Ill., by Otto C. Bixler, Magnecord, Inc., 225 West Ohio St., Chicago 10, Ill.

Binaural Hearing Theory

Basically, the theoretical factors involved in binaural sound presentation are aimed at producing, at a later time, the same sound amplitude and phase relationship in each of a listener's two ears as if he had been present originally. It is to be noted that a listener's ears and brain constitute a directional computing system based upon their phase and amplitude sensitivity. This dual system has a sensitivity-versus-frequency crossover area determined as follows:

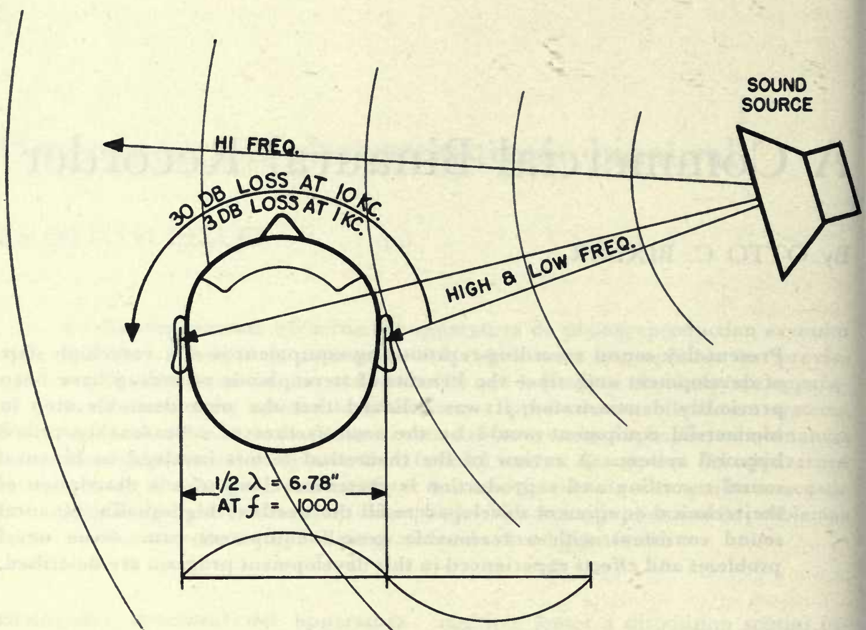

Fig. 1. High frequencies pass by an observer's far ear. Low frequencies readily curve around the cranial obstruction to the far ear.

The average human-ear phase-sensitivity range is from some very low frequency up to approximately 800 to 1000 cycles/sec, which thus allows a perception of directivity by binaural phase comparison over this range. The amplitude sensitivity range of the individual ear is from the lowest frequency perception point up to the highest frequency perception limit within the dynamic volume range of the ear. This dynamic volume range is defined by the standard Fletcher-Munson hearing curves modified by the room masking noise level.[1]

By simple amplitude comparison a mental computation of directivity may be obtained, except as limited by the physics of sound propagation. This means that due to the lack of directivity of low-frequency sounds below, say, 800 to 1000 cycles, the ear's amplitude-detection ability is of no avail, since a low-frequency sound wave curves around the head without appreciable amplitude loss. Therefore, the amplitude-derived directional sensitivity of the binaural ear arrangement falls off rapidly. This is exemplified by the fact that a 1000-cycle/sec tone directed toward a listener from one side of his head produces only a 3-db level difference at his far ear compared with the near ear; a 10,000-cycle/sec tone under the same conditions produces a 30-db level difference (Fig. 1).

It may be shown that the portion of normal auditory perspective due to phase sensitivity is related to the lineal distance between the human ears. Let us assume that a theoretical observer has a between-the-ears distance of, say, 6.78 in. Under certain environmental conditions the speed of sound in air is, say, 1130 ft/sec. The maximum frequency, f, that the ears may compare

phase on, has a half wavelength, $\lambda/2$, equal to the distance between the ears (Fig. 1). Therefore, if:

$$\lambda = 6.78 \times 2/12; \quad \text{then } f = \frac{1130}{\lambda} =$$

$$\frac{1130}{6.78 \times 2/12} = 1000 \text{ cycles/sec.}$$

That is, the maximum possible frequency for binaural phase detection by this theoretical observer is in the order of 1000 cycles/sec or less.

Most speech sound sources possess frequencies both above and below the crossover frequency range of from 800 to 1000 cycles. Not only does this enable the observer to compare angular location by both phase and amplitude methods (and to derive a more accurate location), but since phase shift of a given frequency is a function of both angular position as well as distance, it provides a measure of the distance to the sound source.

In addition to the localization system defined by the base distance between the ears and the mental computation of angles, the mind has an additional distance-computing ability based upon the ratio of direct sound to reverberant sound impinging upon the eardrum.

Microphone Placement

In view of the above, it becomes immediately apparent that in order to record binaurally for later binaural reproduction some care should be exercised in microphone placement.

The first basic principle underlying microphone placement is that the perpendicular bisector of the line joining the pickup microphones represents the center line of a fictional listener's position. During reproduction, the loudspeaker placement should be such that the perpendicular bisector of the line joining the loudspeakers coincides with the real listener's center line. This arrangement results in both depth and lateral stereophonic "image" location, dependent upon both phase and the intensity ratio of the direct sound picked up by the two microphones.

The second principle underlying microphone placement affects the apparent position of the sound behind the immediate foreground. The distance of the source from a single microphone is also determined mentally by a comparison of the reverberant sound to the direct sound. The most accurate mental calculation is made when this ratio is not in the extremes. Therefore, both exceedingly close and overly distant microphone placements are to be avoided.

Under a strict binaural microphone arrangement the two microphones should be relatively close together and have individual pickup patterns approximating those of the human ear; the placing of an acoustic septum between the microphones would be desirable. Under an expanded arrangement, wherein a simple stereophonic system is obtained, the microphones are spaced quite widely apart and a third microphone with isolation amplifiers and attenuators is added midway between these two primary microphones. The object of the center microphone is to feed a small amount of sound energy to both recording channels and thereby to correct for the spatial distortion occasioned by moving the primary microphones apart.[4] Unless this correction is made, some depth location error occurs, especially in the area midway between the primary microphones. If some depth location error may be permitted, which it may be if the sound is not associated with a concurrent motion picture, then it is readily possible to omit the center microphone.

Binaural Presence — Listening

The physiological sense satisfaction that yields the psychological impression of being present in a nonexistent room is the startling factor in listening to a binaural recording for the first time. The sense of "presence" obtained is

considerably different from the normal usage of this word. In accepted sound practice the reproduction objective is to bring the sound source into the presence of the listener. Listening to a binaural recording can best be described as literally taking the listener into the presence of the scene where the original recording was made.

This effect of realism is particularly effective when listening with headphones. When considering theoretical factors it would not seem that loudspeaker listening would be very effective for binuaral reproduction. However, listening tests readily convince one that considerable enhancement is still retained with speakers although not of such a high order as that of earphone listening. The use of earphones prevents a listener from turning his head to aid in localizing sound sources; loudspeaker reproduction on the other hand allows a listener to retain this mechanical aid to localization. Loudspeaker placement is of considerable importance in good reproduction. The use of too large or too "live" a room or too great a listener distance greatly reduces the effectiveness of binaural loudspeaker reproduction.

Random Noise Correlation

An unexpected effect was noted when some rather poor recordings were unintentionally made and then played back. When the recording medium or equipment random-noise level is high with respect to the level of the recorded signal a unique result ensues. The random nature of this white noise is such that it allows false phase and amplitude coincidence to be correlated by the brain to produce apparently localized sources of noise. The localization means focused listening attention; the effect thus results in raising of apparent loudness of discreet noise "pulses." Since these pulses are strictly random mental correlations, their number is far less than the actual number of white noise "pulses"; therefore, the net effect is a coarsening and apparent increase of the background noise level to the listener. Practically speaking, this means that binaural recordings made for maximum music appreciation should be made with particular care toward maintaining the best overall measured signal-to-noise ratio.

The Tape Transport

The development of the binaural tape transport from a standard recorder was very desirable in order to keep manufacturing costs down and allow sales at a reasonable price to the customer without the necessity for designing a new special unit with its attendant reflected high sales price. It was found possible to extend the development of a standard Magnecord PT63-A tape transport mechanism for use in a binaural recording system. This basic tape transport mechanism possesses an assembly incorporating three heads. The tape passes in succession over, first, the erase head, then, the normal recording head, and, thence, over the tape monitor head before it is pulled by the capstan and fed to the take-up reel.

Consideration was given to the possibility of retaining the tape monitor feature for the binaural system. However, it was determined that the additional system complexity would add materially to equipment size and costs because of the immediate requirement for two monitor heads and two amplifier monitoring channels as well as extra controls. The mechanical layout of the front panel of the existing PT63-A tape transport unit would also be unduly complicated by the addition of the two extra magnetic heads required. It was, therefore, decided that the normal full-track record head would be replaced by a half-track record head and the position normally occupied by the monitor head would be used for a second half-track record head for the other half of the tape.

It is of interest to note that in this standard unit the erase head forms the principal load for the 60-kc erase and bias oscillator with the record head bias coil being a relatively small series impedance in the circuit. It was therefore possible to add the bias winding for the second recording head in series with the existing erase and record heads without any appreciable net change in bias or erase currents. Using the above-described arrangement it was then only necessary to supply proper pole pieces, and to reconnect the internal wiring to the heads to accommodate the second recording channel. Plug and receptacle arrangements are so chosen as to automatically maintain channel identity in the interunit cables.

With the exception of the nameplate, there is no apparent difference between a binaural Magnecorder and a normal single-track unit unless the magnetic head covers are lifted to allow a view of the half-track pole pieces which do the recording. The half-track pole piece consists simply of a normal full-track pole piece with approximately $\frac{1}{2}$ of the Mu-metal cut away and a brass insert soldered into its place in order to fully support the tape.

The Amplifier Unit

The development of a binaural recording and reproducing amplifier was essentially a specialized packaging job which involved building a new portable dual amplifier unit, each amplifier having all the characteristics of existing unit standard amplifiers. The packaging was accomplished with only a minor increase in space and weight for the dual amplifiers over that required by a similar existing single-channel amplifier. The latest techniques in the use of miniature tubes and components were employed in the manufacture of this equipment. Individual illuminated VU (Volume Unit) meters were provided for each recording and reproducing channel as well as individual gain controls.

A unique problem in the design of this unit arose due to the necessity for providing an overall or master gain control which controlled simultaneously the gain of both channels. This was accomplished through the use of a special dual potentiometer with matched rotational ohmic accuracy in the order of plus or minus 5%.

Provision was made for headphone monitoring from the front panel of the amplifier through the use of specially built Permoflux binaural headphones having an effective response to over 12,000 cycles/sec. These headphones are provided with large foam-rubber ear cushions in order to exclude extraneous noise and to reduce the well-known head fatigue that comes from the use of ordinary earphones. Dual monitor speakers close together on a small panel would not yield any useful binaural effect and might be dangerously confusing for monitoring use. Therefore, in addition to the binaural headphones, a single small monitor speaker is provided behind a flocked screen panel on the front of the amplifier. A unique control is included for this speaker which is so arranged that it is "off" when set at its center position. Maximum volume for one channel is obtained by turning the control to the extreme right, and maximum volume for the other channel, by turning the control to the extreme left.

The amplifier tube lineup for a single amplifier channel consists of two 5879 tubes followed by a dual triode 12AX7, the second half of which is used as an inverter driving a pair of push-pull 6AQ5 tubes. The same amplifier is used for playback as well as recording. A multiple section (shielded between sections) ganged selector switch is used to switch equalizer and gain functions for the dual amplifiers when changing from the record to playback positions. In order to provide freedom from hum in the low-level stages of the amplifiers, direct current is used on the filaments of

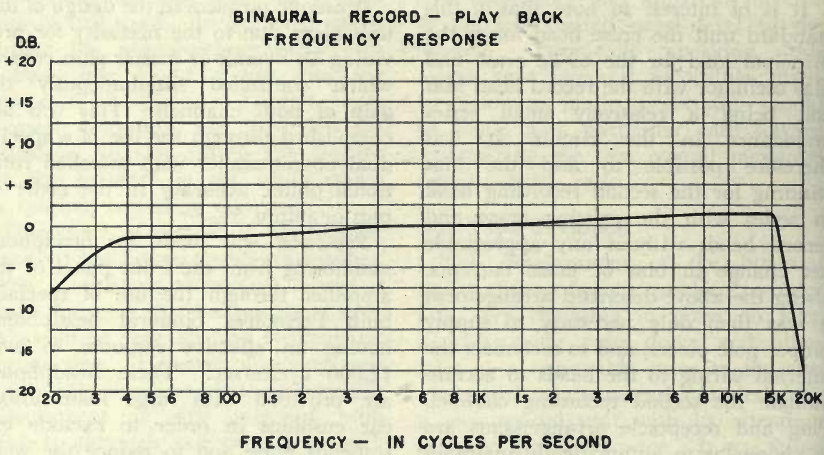

Fig. 2. Overall 15-in./sec tape speed, record-reproduce frequency response.

the input tubes. This is derived from a full-wave selenium rectifier.

The output of the playback system consists of two independent 10-w amplifiers with nominal output impedance of 4 and 16 ohms. A 600-ohm balanced connection is also provided at a line level of +4 dbm for each channel. The system is both pre- and post-equalized in order to achieve a flat response at 15 in./sec recording speed of from 50 cycles to 15 kc ± 2 db (Fig. 2). Both the amplifier unit and the tape transport are provided with facilities which allow operation at 7½ in./sec with a frequency response of from 50 cycles to 7.5 kc ± 2 db.

A signal-to-noise ratio in the order of 50 db is achieved with this equipment. The residual crosstalk between channels is essentially due to low-frequency magnetic coupling below 100 cycles/sec. This crosstalk measures approximately 35 db at 50 cycles and drops with frequency increase until it goes below the tape noise level at a little over 100 cycles/sec.

Calibration Means

In order to assure accurate localizing based upon binaural amplitude comparison, it is desirable that all possible electronic balancing between the two record-reproduce channels be carried out. To this end, a calibration button is provided which inserts a 60-cycle/sec signal simultaneously into the first stages of both amplifier inputs. The channel gain controls may then be individually adjusted to obtain equal VU meter readings. The balanced signals may then be recorded if the tape transport is turned on. When played back, the two 60-cycle signals may again be read on the VU meters and the playback gain controls may then be balanced for the optimum binaural effect.

Commercial Applications

The design of this equipment was aimed at satisfying certain specific commercial applications although it has a definite application to high-fidelity music recording-reproducing, where listening pleasure is desired to be as high as possible. The majority of commercial applications lie in the field of identification of intelligence or information where it is necessary to distinguish between each of many

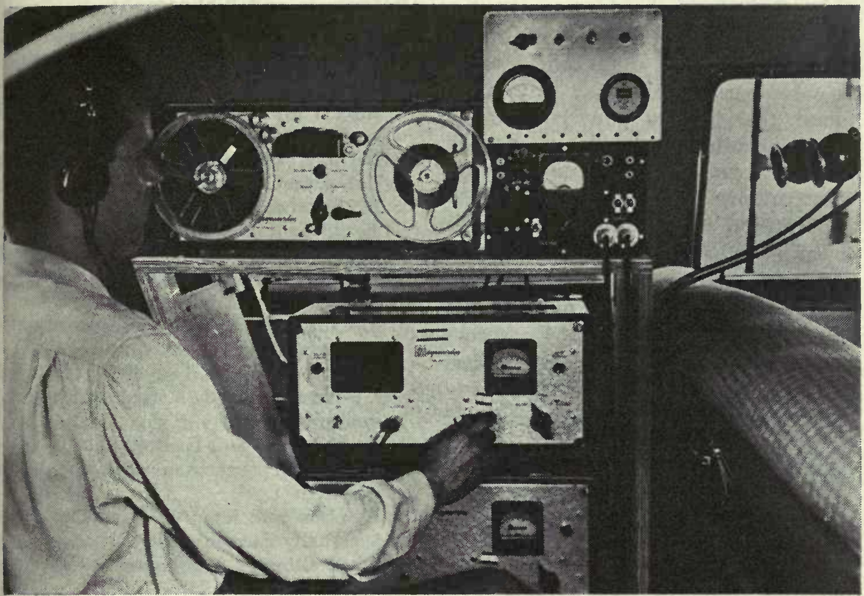

Fig. 3. Binaural recorder in field use by auto manufacturer testing for noise.

sound sources which may be spread around a given area.

Court recording is one very important and useful application of this equipment. With it, accurate records including differentiation between the various persons in a courtroom may be made. A study by Ray Hirst[6] of monaural court recording has shown that too often court records are at variance with what actually transpired because the court clerk was unable to follow testimony fast enough to accurately transcribe data as it was presented; or because the clerk heard something wrong; or because the clerk simply made a mistake. On one occasion, to our knowledge, it was necessary to reverse the written record due to a stenographic error. Application of this equipment to a Court of Justice would help to improve the carrying out of justice. We have carried out courtroom tests with very effective results and have some excellent demonstration tapes.

Another application of this binaural technique is that used by police and secret-service departments for secret recording of conversations. The standard accepted methods of masking a voice's intelligibility are by the use of continuous tapping noise, by the running of faucet water or by the turning up of a radio for background masking noise. A monaural system cannot distinguish between the masking noise and the intelligence it is desired to detect. A binaural system localizes the attempt at masking and allows the listener to associate direction with the desired sound so that he may achieve intelligibility.

Business, technical or military conference proceedings are a natural for this type of recording since the data may later be transcribed by a stenographer with considerable freedom from error caused by simultaneous talking or masking. A stenographic transcription may be made of two people talking simultaneously since by mental localization the stenographer may concentrate

on the speakers one at a time and then play back the recorded material a second time to get the second speaker. In some recently conducted tests it was found that if two conversations are simultaneously recorded, a capable operator can produce an accurate transcription even when the desired conversation was recorded at a 13-db lower level than the unwanted dialogue.

In radio and motion picture work the second recording channel may be used as a cue or control track for special effects or for recording commentary along with the primary intelligence.

In the laboratory or for field-test work the binaural equipment may be used for recording either binaural or dual-track test data for later careful analysis. Figure 3 shows a binaural recorder in field use by a prominent automobile manufacturer. Note that this setup shows the predecessor to the dual-channel amplifier unit.

The field of audio-visual education utilizes realism as a teaching aid. This portable binaural packaged system readily lends its "third-dimensional" sound reality to assist in critical analysis of band or choir practice, speech classes, dramatics, etc.

Conclusion

1. No appreciable sacrifice in quality from that of a standard $\frac{1}{4}$-in. tape recording system was necessary in these units.

2. The resultant equipment as manufactured is really of a portable nature and is housed in two carrying cases. The amplifier unit weighs but 37 lb, while the tape transport has a weight of 29 lb.

3. From the foregoing data, it is apparent that the design objectives of producing a practical but low-cost commercial binaural record-reproduce magnetic tape equipment were accomplished.

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   E. C. Wente and A. H. Müller, "Internally damped rollers";
   L. A. Elmer, "A non-cinching film rewind machine."
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Discussion

R. H. Ranger (Rangertone, Inc.): Through the courtesy of the Magnecord Company, I have had the privilege of using one of these equipments and I want to say that it is certainly most intriguing to have the opportunity to do so. The particular reason they were anxious to have me try it was to see if we could record a synchronizing signal on this same tape and I can report to you people who are obviously very interested in synchronizing that it is quite feasible. We have recorded the longitudinal track in the center between the other two tracks, so that you can get synchronous operation using this binaural equipment.

I might just add one little reaction that I have had with it and which I confirmed with Dr. Fletcher just yesterday in New York, and that is that not only is it interesting to get two speakers differentiated spatially by this process, but the actual quality of a single speaker, a single person singing, or a single instrument seems to be improved. As Dr. Fletcher said, "I'm too old to figure that out. We'll have to leave that to the younger people."

Anon: Is there any provision in your equipment for playback on one channel while recording on the other?

Mr. Bixler: No, there is not at the present time.

Anon: I have asked that only because there are several applications for which I think that would be a very useful feature. One of them, for instance, is prescored accompaniment in music, while the person practices his solo beside it.

Mr. Bixler: I might say that there is a single multiple contact selector switch which is used to switch both channels simultaneously from record to playback, and that you could do what you suggest if you were to go into the circuit and build in two switches, in place of this single switch along with some other minor modifications.

C. H. Lankester (United Nations): In view of the fact, as I understand it, that there is a longitudinal displacement between the record heads, have you found it possible to standardize a positioning of the two heads perfectly accurately, that a binaural recording made on that recorder would play back on another without loss of the binaural effect?

Mr. Bixler: I might say that the speed of the tape actually helps in this respect because it's relatively fast and each wavelength covers quite a bit of tape when you "lay" down the signal. On the other hand, heads are supported in fixed castings so that these same patterns are used in all our machines — it's the standard casting we've been using for years, so that insofar as our equipment is concerned, the location of the heads automatically falls in identically the same position in each and every machine. If there is some minor spacing difference the speed of the tape is sufficiently great so as to swamp that difference out.

John G. Frayne (Westrex Corp.): I would like to ask Mr. Bixler if he found it impossible to put the two separate heads in the same head structure because the crosstalk between them would then be undesirable.

Mr. Bixler: Well, yes and no. I imagine if we had tried to put them right alongside of each other we would have had some crosstalk and I looked with interest at Charlie Davis' disclosure in a recent SMPTE *Journal*, but it was a matter of expediency in utilizing present equipment and space location on existing castings on which, as I mentioned, we simply replace the existing record and reproduce monitor heads in standard equipment. Thereby it turns out that the heads are spaced from about one-half to about three-quarters of an inch apart automatically.

Dr. Frayne: What is the separation now between the two half-tracks — between the two components, rather, approximately?

Mr. Bixler: I don't know.

John Boyers (Magnecord, Inc.): 50 thousandths of an inch.

Mr. Bixler: Thank you, John.

Dr. Frayne: I believe that with about 50 thousandths separation you might work in the decoupler such as Davis discloses.

Mr. Bixler: Yes, that is if we had heads that were suitable for that type of mounting.

Follow-Focus Device and Camera Blimp for 16mm Professional Camera

By LEE R. RICHARDSON and WILLIAM N. GAISFORD

A novel system of lens focusing, coupled with a synchronized parallax correction cam and focusing viewfinder, is accomplished by the use of planetary gearing to the lenses which also permits fast shifting of lenses without disengaging any cams, gears or footage dials. A plastic camera blimp for the 16mm professional camera and follow-focus mechanism is introduced which reduces the noise level to permit professional sound cinematography.

PRODUCERS OF 16mm television and industrial films are frequently confronted with the problem of photographing a live show, sporting event or other unrehearsed productions which cannot be repeated. In many instances when filming these shows, it is necessary to follow a moving subject which may move toward or away from the camera making it necessary to keep the subject in proper focus and suitably composed on the film. Further, a camera blimp is often required which will reduce the noise level of the camera to permit sound recordings under the most critical sound conditions.

The Raphael G. Wolff Studios of Hollywood, producers of television and commercial productions, were faced with problems similar to the above. After consultation with the Richardson Camera Co., they submitted specifications for a follow-focus device and camera blimp for a Maurer 16–05 Professional Camera equipped with 15-mm $f/2.5$, 25-mm $f/1.4$ and 40-mm $f/1.4$ Eastman Cine Ektar lenses.

The Wolff Studio's specifications called for the development and manufacture of a mechanism to permit follow-focusing of each lens of a multiple-lens turret through their focusing range (3 ft to infinity), provide a simple and efficient means of shifting to another lens of a different focal length at any time, maintain the same focus setting as the preceding lens without interfering with the functions of racking over the camera or threading the film in the camera and enable the operator to keep subjects constantly in sharp focus and suitably composed on the film as the distance between subject and camera position varies even though the subject may move away from or toward the camera in a direct line or at an angle.

Presented on April 25, 1952, at the Society's Convention at Chicago, Ill., by Benjamin Berg for the authors, Lee R. Richardson and William N. Gaisford, Richardson Camera Co., 1065 N. Fairfax Ave., Hollywood 46, Calif.

The requirements of the blimp were to contain the camera and follow-focus mechanism and be constructed of a sound deadening material, be light-weight, and reduce camera noise interference to a level permitting the use of a microphone within 3 ft of the camera.

The Maurer Camera was ideally suited to this project as it comes equipped with a focusing viewfinder with a parallax compensating mechanism.

Design and Construction

A planetary system of gearing was selected as it made possible the functions of keeping the entire gear driving mechanism and viewfinder linkage permanently engaged. The fact that all three lenses are caused to rotate simultaneously in their mounts is not objectionable (Fig. 1).

Each lens was set up in a dividing head and the amount of rotation from the 3-ft mark to the infinity mark were obtained in order to determine the correct gear ratios for synchronizing the lens calibration with the focusing dial and control knob.

The main drive gear consists of a ring gear having both internal and external gear teeth of 48 pitch with annular ball races ground on both faces of the gear and loaded with 480 $\frac{1}{16}$-in. steel balls. Two retaining gear rings are grooved to match the ball races which hold it in place on the front of the camera case. The balls are slightly preloaded to allow the ring gear to rotate with minimum friction and no end play.

Compound gears of proper ratio are driven by the internally cut teeth of the ring gear and are ball-bearing mounted on fixed stud shafts attached to the lens turret plate. These gears in turn mesh with the ring gears attached to the lens focusing barrel.

A gear transfer case transmits motion from the control knob and dial assembly to the externally cut teeth on the ring gear and also to a master cam plate gear housed in the subbase of the camera. These two gears are synchronized with a ratio of one to one.

The master cam plate has three scrolls (Fig. 2) each generated and cut to act upon a cam follower and linkage to the Maurer focusing viewfinder. The cam is spring loaded against the scroll to eliminate backlash.

The viewfinder was modified to function with a minimum of friction and backlash by removing the rack and pinion and replacing the dovetailed slides with ball rollers. As the Maurer viewfinder has two parallax compensating cams, one for the wide-angle lens, 15-mm, and the other for the 25-mm and 40-mm lenses, an adjustable linkage was provided for manually shifting the finder only for the wide-angle lens.

The control knob and dial assembly is one detachable unit and can be mounted on either the left or right side of the camera. A splined coupling permits engaging the control unit to several reading angles.

Operation

A simplified sketch is shown (Fig. 3) which illustrates the basic principle involved in the operation.

Control knob (a) drives gear (b) which in turn rotates internal ring gear (c) causing gears (d, e, f) to rotate, in turn causing gears (g, h, i) to revolve. By proper gear ratios, (g, h, i) rotate lens focusing barrels (j, k, l); thereby, keeping all lenses synchronized in respect to their focusing range from infinity to their nearest focal point. When lock (n) is released from notch in turret plate, and control knob (a) is rotated in either direction, the entire lens-mount assembly attached to the mounting plate (m) will rotate until by-pin (n) drops into next indexing notch in plate (m). All lenses will remain in the same synchronized focus position as the lens mount assembly is shifted from one lens to another because the resistance of the lens-focusing barrels and the gearing will overcome the lighter

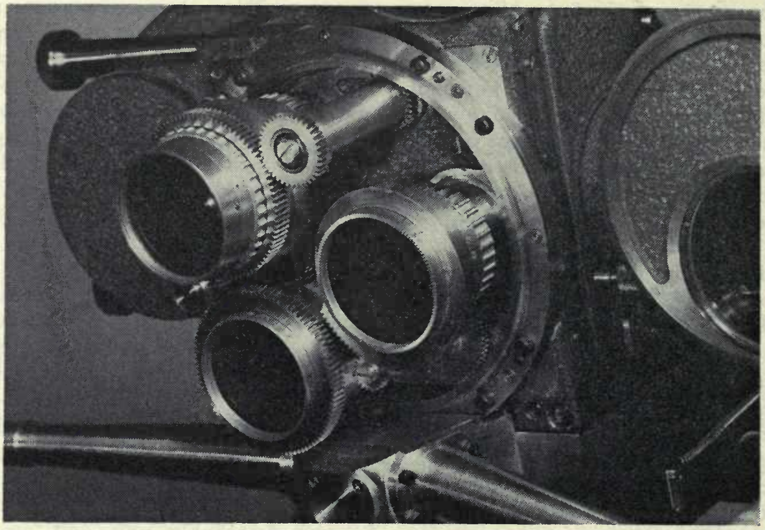


Fig. 1. Planetary gearing system to lenses.

Fig. 2. Master cam plate and viewfinder linkage.

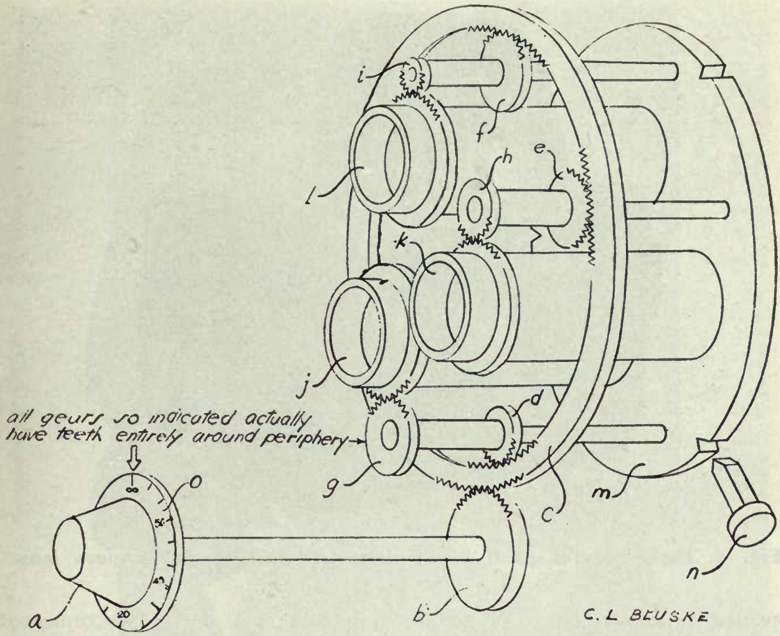


Fig. 3. Schematic drawing of basic principle of planetary gear system.

friction of the mounting plate (m). In shifting from one lens to another, the focus dial (o) will rotate one complete revolution thereby returning to the same distance calibration as the preceding lens.

Example: In the case of a three-lens turret assembly, as illustrated, the gear ratio between the control knob (a) and the internal ring gear (c) is 3 to 1 with three indexing notches on the lens turret plate, one to index each of the three lenses. Focus dial (o) will rotate one complete revolution in shifting lens-mount assembly to next lens. This will allow the use of only one focus dial for all three lenses.

The follow-focus operation incorporates, in addition to the foregoing system of lens focusing, a method of actuating the focusing viewfinder so that the optical elements of the finder sharply focuses the image on its viewing glass in synchronization with the lens focusing of the image on the film.

A stop pin within each lens mount prevents the lenses from rotating beyond their infinity position. This in turn prevents the control knob from being further rotated due to the lens turret plate assembly being locked by the turret locking pin. When a release button is pressed and the control knob turned, the entire lens turret assembly rotates until the next lens is in place, indexed and locked by the turret locking pin. Synchronized with this function is the cam follower which rides out of its cam scroll into an inclined circular groove and drops down into the next cam scroll and is synchronized to the next lens that comes into place.

The linkage from the cam follower to the focusing viewfinder is so constructed to permit racking over the camera for lining up a scene and also

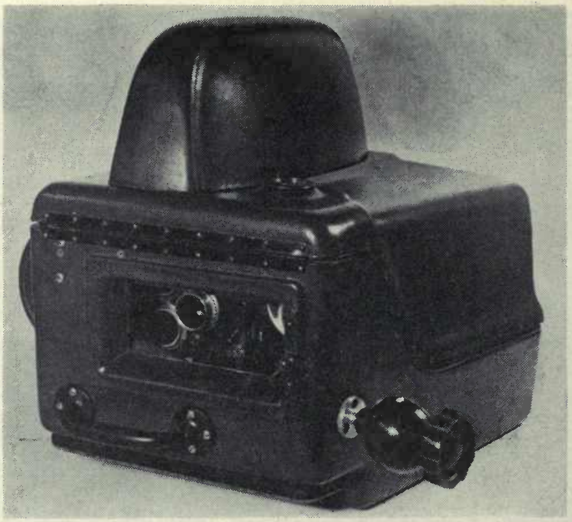


Fig. 4. Three-quarter front view, showing window over camera lens.

for opening the camera door to rethread the film. The viewfinding actuating cam scrolls were generated to their respective lens-focusing distances at the full lens opening. The depth of the field of the lenses allows for normal human error in follow-focusing on a moving subject or when the camera is mounted on a moving platform in relation to a fixed subject.

Camera Blimp Design and Construction

The component sections of the blimp (Figs. 4 and 5) were designed to take advantage of the simplified method of fabrication which is possible with Royalite Plastic, a product of the U.S. Rubber Co.

The base and cover sections are reinforced with an aluminum frame giving additional strength and support for the cover hinge. The interior of the blimp is further soundproofed with Royalite expanded plastic and finished off with a corduroy covering. A rubber grommet, around the edges of the lower part of the blimp, acts as a seal when the cover is closed. The camera mounting base is a steel plate cemented to the inner base of the blimp with a $\frac{1}{2}$-in. thick pad of neoprene sponge rubber between. Guide rails are attached to the base plate to register the camera when installing in the blimp. An aluminum alloy plate is rubber bonded to the bottom of the blimp providing a firm support for the entire unit when mounted on a tripod, camera dolly or platform.

Other main features of the blimp are: (1) an optical glass window which is hinged permitting access to the lenses for setting *f* stops; (2) portholes for observing *f*-stop markings when blimp cover is closed and to check on magazine take-up wheels; (3) external control for turret release button; (4) pilot light to illuminate the interior of the blimp when making lens adjustments, threading, etc.; (5) jeweled indicator lights which show when camera motor is running and pilot light is on; and (6) windows in the rear of blimp for looking through viewfinder, checking shutter openings and footage counter.

Fig. 5. Side view, showing control knob and dial assembly.

Comments

The Richardson Camera Co., when designing the lens-focusing system, were aware of the discrepancies between the three lenses. The problem, however, was not to construct an absolutely accurate focusing system as would be required on precision optical printers but to provide an efficient, simple and quick method of follow-focusing for the cinematographer on action shots.

In focusing a lens on a variable moving subject, it is necessary for the camera man or his assistant to estimate or determine by some visible means the distance between the camera and subject. He must then transfer this information to the lens-focusing control knob or footage dial all of which involves a human function with limited accuracy. The depth of focus of the lens in use is intended to permit a

certain amount of error in the judgment of the operator.

The designers increased the accuracy of the mechanism by calibrating the footage dial to the longest focal length lens used, 40-mm at $f/1.4$ stop. Obviously, where critical focusing is required, the camera is racked over and the subject aligned and focused on a ground glass. This is the most accurate means of focusing and does not depend on footage calibrations engraved on the lens. This means of focusing cannot be used when the subject or camera is in motion.

Conclusions

The follow-focus device was found to be exceedingly efficient as to the accuracy of the mechanism and as to simplicity and time-saving in operation. The knowledge that the lens parallax and distance calibrations are at all times synchronized gives, to the operator, assurance that a sharp focused and composed image is properly recorded on the film.

The lightweight plastic blimp was tested on a sound stage under normal operating conditions and found to be equal in performance to other blimped professional motion picture cameras. In most cases, the front glass was left off and still the camera noise was below the ambient sound noise of the stage making it possible to record dialogue with the microphone within 3 ft of the camera.

Acknowledgments

The authors wish to acknowledge the sponsorship of this project by the Raphael G. Wolff Studios, to Mr. Wolff personally and his camera technicians Art Treutlaar, Gail Papineau and Henry J. Ludwin, all of whom outlined the essential requirements incorporated in this design. Charles L. Bluske, industrial designer, styled the camera blimp. John Roy of the U.S. Rubber Company gave technical advice on fabricating Royalite Plastic material. The Glen Glenn Sound Co. gave its sound stage facilities for testing the performance of the equipment.

Instantaneous Theater Projection Television System

By VICTOR TRAD and RICARDO MUNIZ

A new, inexpensive, instantaneous dual theater projection television system of the Schmidt type is described. A simple control box providing almost instantaneous change-over, in the event of breakdown, and mechanical arrangements facilitating ease of installation and maintenance are discussed.

A STUDY of the needs of the motion picture theater owner and operator made over a period of many years, in connection with the development of this and earlier projection television units, has revealed the need for a thoroughly satisfactory and reliable theater projection television unit which will, at the same time, be substantially lower in cost than those others currently available, and which will be amenable to relatively simple installation techniques, and which can be supplied and kept in adjustment easily by the motion picture projection machine operator. This paper presents some of the technical and operational features of the present Trad theater television unit.

It will be seen that, in this typical installation (Fig. 1), the Trad dual unit rests upon a simple support bracket which, in turn, has been attached to the main balcony support of the theater.

This places the unit in the proper operating position with respect to the theater screen, and also provides maximum accessibility from the balcony of all adjustments and chassis for routine operation and maintenance.

Figure 2 shows how the two chassis, the low-voltage power supply with video amplifier and the high-voltage sweep chassis, are mounted with relation to the projection optical system, and also how accessible the units can be from the balcony without the use of ladders or scaffolding.

The various electronic adjustments are located in the rear of the high-voltage sweep chassis and, once made, need be checked only at infrequent intervals, but which are conveniently accessible from the balcony since they are on the side of the chassis nearest the balcony. It is important to note that this is the only place in the entire installation where any high voltage exists. It is not necessary to have elaborate high-voltage transmission sys-

Presented on April 21, 1952, at the Society's Convention at Chicago, Ill., by Frank H. Riffle for the authors, Victor Trad and Ricardo Muniz, Trad Television Corp., 1001 First Ave., Asbury Park, N.J.

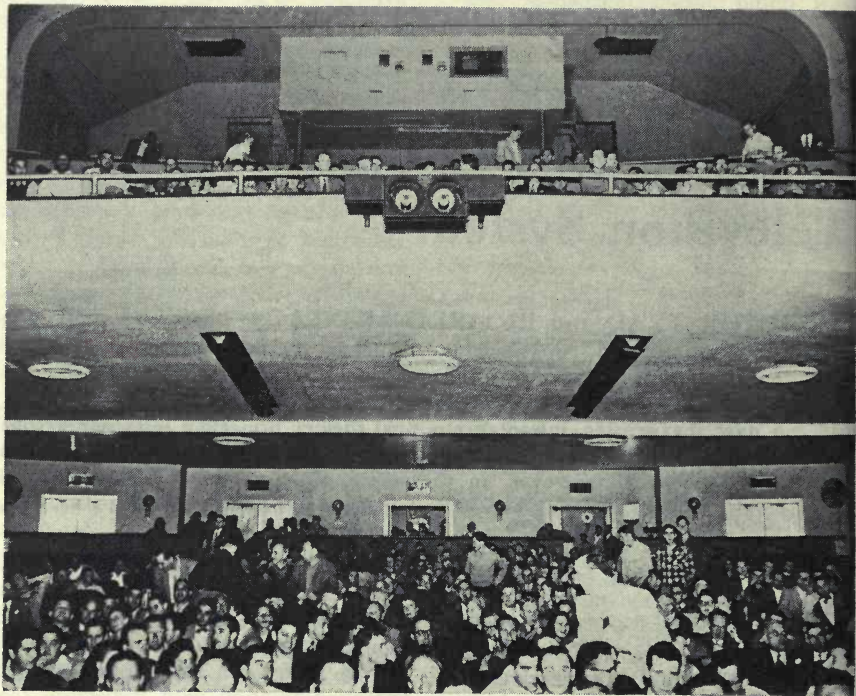


Fig. 1. A theater installation, showing the dual unit mounting.

tems nor protective devices with the Trad theater television unit.

The remote-control unit (Fig. 3) is mounted in the motion picture projection booth near one of the port holes. This remote-control unit provides for the adjustment of contrast, vertical and horizontal hold, and also for the switching from one of the dual units to the other, in the event that any trouble develops in the one in operation. It is here that the operator stations himself and it is these controls alone which he will find it necessary to manipulate during the normal operation of the equipment.

Signals are provided by a monitor, Fig. 4, containing a television receiver and providing video amplification for any remote programs from either microwave link or the coaxial cable. It also provides a third service in that the television receiver which it contains, when connected to a suitable antenna, can provide off-the-air signals from local television broadcasters, should these be required.

Getting back to the main unit, Figs. 5A and 5B show some of the unique features which have resulted from the long practical experience with this type of device. The patented Trad theater projection television unit was designed not only from the standpoint of operational simplicity but also to project the greatest possible amount of light from the projection tube to the screen.

As can be seen, the obstacles to the reflected rays of light have been minimized. It is interesting to note that, with a mirror diameter of 14 in. and a focal length of 6.6 in., the effective

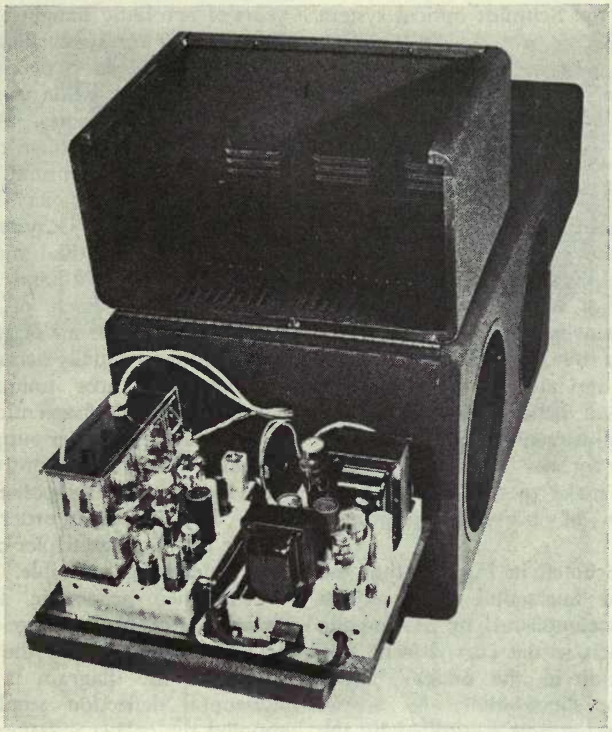


Fig. 2. Close-up of one side of the unit, with protective hood open.

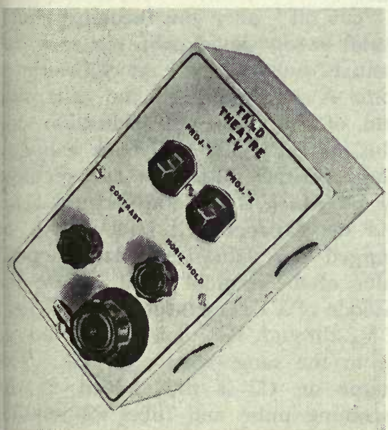


Fig. 3. Remote-control unit.

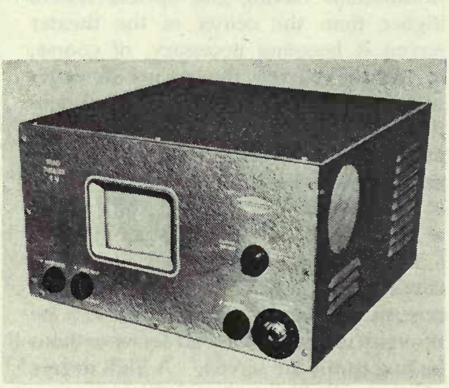


Fig. 4. The monitor.

aperture of the Schmidt optical system used is $f/0.85$.

$$f = \frac{\text{focal length}}{\text{effective diameter}}$$

$$f = \frac{6.6 \text{ in.}}{7.77} = 0.85$$

Light-meter readings taken at the surface of the corrector plate are 160 ft-c. The optical barrel provides for adjustments of vertical and horizontal centering, conveniently accessible from the balcony by swiveling and tilting the barrel, and also for overall top-to-bottom optical focus. The convenience of these adjustments can be readily appreciated by any user who has attempted to make these adjustments on other types of television projection barrels.

It will be noted in Fig. 5A that the vertical and horizontal focus adjustments are accomplished by moving the "dish," which is the curved-front surfaced reflector in the optical barrel, vertically or horizontally by screw-operated mechanisms controlled by the two knobs shown for each direction. Similarly, as in Fig. 5B, the optical focus control has been brought forward by mechanical means so that a simple knob within easy reach of the balcony is all that need be controlled. In installations having the optical system higher than the center of the theater screen it becomes necessary, of course, to tilt the barrels downward in order to throw the picture within the dimensions of the screen. In doing this it is found that, if the optical focusing adjustment is carefully set for the center of the screen, the top and the bottom of the picture are somewhat out of focus.

By adjusting the vertical and horizontal focus adjustment knobs in the rear of the barrel, the picture can be brought into good overall focus without having to tilt the screen. A high degree of "practical" engineering has gone into the Trad barrel as a result of many years of acrobatic hanging by one foot from theater roofs, perching on the top of fire-engine ladders or chinning oneself on a trapeze while using the teeth for adjustment purposes. So, here now is a barrel which doesn't require an acrobat, or any unusual courage or skill to operate. It may be noted in passing that there is symmetry about the center of the dual unit, with the left-hand and right-hand units being mirror images. Each of them independently provides all of the necessary adjustments in equally accessible form.

There are three unique technical features worthy of attention: (1) the high-voltage multiplier supply; (2) the automatic brightness control; and (3) the video amplifier response characteristics. Taking these in order:

The high-voltage tripler operates on a very interesting principle. Figure 6 is a simplified schematic showing the operation of the voltage multipliers. It will be noted that the 6BG6 tube shown in the diagram is one of the horizontal deflection amplifiers which supplies the proper waveform of current to the horizontal deflection coils, which cause the electron beam to scan the face of the cathode-ray tube horizontally during operation. At the end of each horizontal line, the 6BG6 plate current is "cut off" after the incoming horizontal sweep signal drops to zero. A positive pulse of voltage appears at point A as a result of the collapsing field of the horizontal deflection coil (this is a kickback or flyback voltage). These positive pulses are first rectified by V1 which is a diode vacuum tube, and the capacitor C1 is found to be charged to a value very near the peak value of the original pulse. Since the cathode of V1 is connected to the plate of V2 through R1, then C2 will charge up to the same voltage as C1. The charge on C2 is thus added to the oncoming pulse and tube V2 rectifies the sum of these voltages, thus charging capacitor C3 to double the original pulse

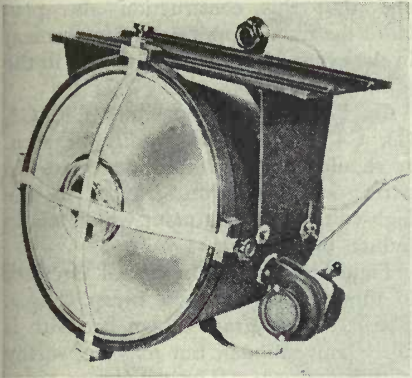


Figure 5A.

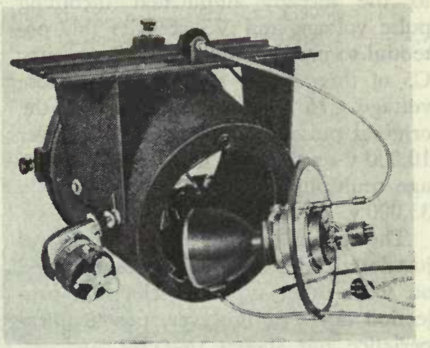


Figure 5B.

Views of the optical barrel.

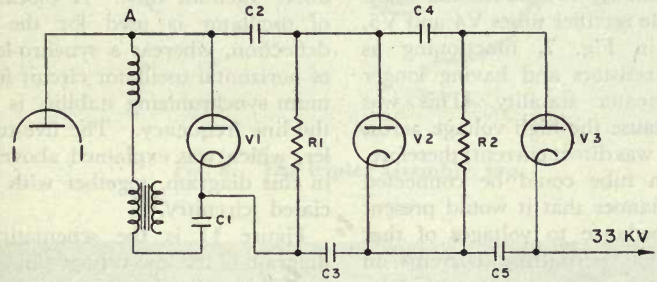


Fig. 6. Simplified diagram of the high-voltage tripler.

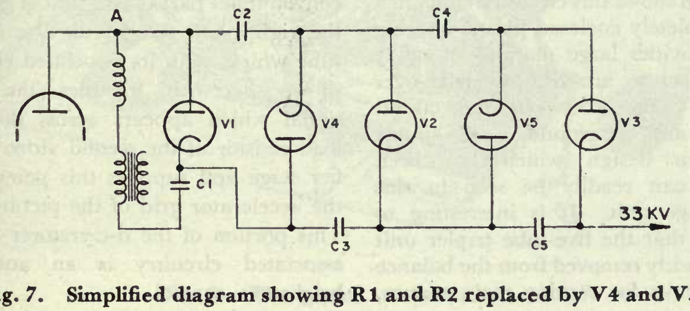


Fig. 7. Simplified diagram showing R1 and R2 replaced by V4 and V5.

voltage. The charge on C4 is added to the already duplicated incoming pulse voltage and V3 rectifies this potential to produce a charge on capacitor C5 of three times the incoming pulse voltage. In the case of this unit, the original pulse voltage is somewhat over 10,000 v so that the output of the voltage multiplier system is approximately 33,000 v.

The type of voltage tripler which was just described is conventional and is used on some other types of television projection devices; however, practical experience has shown that R1 and R2 have such high voltage gradients that it is next to impossible to obtain resistors which will have long life and which will retain resistance stability for a reasonable period. Therefore, in the interests of maximum reliability, these resistors have been replaced in the Trad unit by two additional high-voltage diode rectifier tubes V4 and V5, as shown in Fig. 7, functioning as thermionic resistors and having longer life and greater stability. This was possible because the high voltage across the resistors was direct current; therefore, the vacuum tube could be connected in such a manner that it would present a high impedance to voltages of that polarity while permitting currents in the reverse direction to flow with relative ease. Thus the vacuum tube provides a higher inverse resistance than would have been practical with resistors and still have the advantage of a low impedance in the reverse direction.

Figure 8 shows this circuitry embodied in a completely enclosed plastic housing which provides large margins of safety with respect to arc-over or strike-over of high voltage between the circuit elements and/or ground. The simple and clean design which has been achieved can readily be seen in this high-voltage unit. It is interesting to note also that the five-tube tripler unit can be readily removed from the balance of its circuits for routine maintenance, and that this construction also provides the maximum ease of replacement in the event of any form of failure in the unit.

In Fig. 9, the capacitors C1, C2, C3, C4 and C5 can readily be seen. It should be noted that there are no wires or other protuberances in the high-voltage compartment which would induce breakdowns.

Figure 10 shows the actual circuitry in the high-voltage and sweep chassis. The circuit diagram shown herewith is fairly conventional, but may be worthy of a few words. The composite video signal has had the synchronizing information stripped from it in the associated low-voltage power supply unit, shown in Fig. 11. This synchronizing information is fed into the unit shown and separated into both horizontal and vertical synchronizing pulses by the 6SN7 vacuum tube. A blocking type of oscillator is used for the vertical deflection, whereas a synchro-lock type of horizontal oscillator circuit for maximum synchronizing stability is used for the line frequency. The five-tube tripler, which was explained above, is seen in this diagram, together with its associated circuitry.

Figure 11 is the schematic circuit diagram of the low-voltage power supply and video chassis. It will be noted, a two-stage video amplifier with series and shunt peaking is provided, and that a d-c restorer of conventional design as well as a synchronizing stripper are incorporated on this chassis. The unconventional part of this unit is given on the right-hand side of the d-c restorer tube which, with its associated circuitry shown herewith, rectifies the video signal which appears across the plate load resistor of the second video amplifier stage and supplies this potential to the accelerator grid of the picture tube. This portion of the d-c restorer and its associated circuitry is an automatic brightness control.

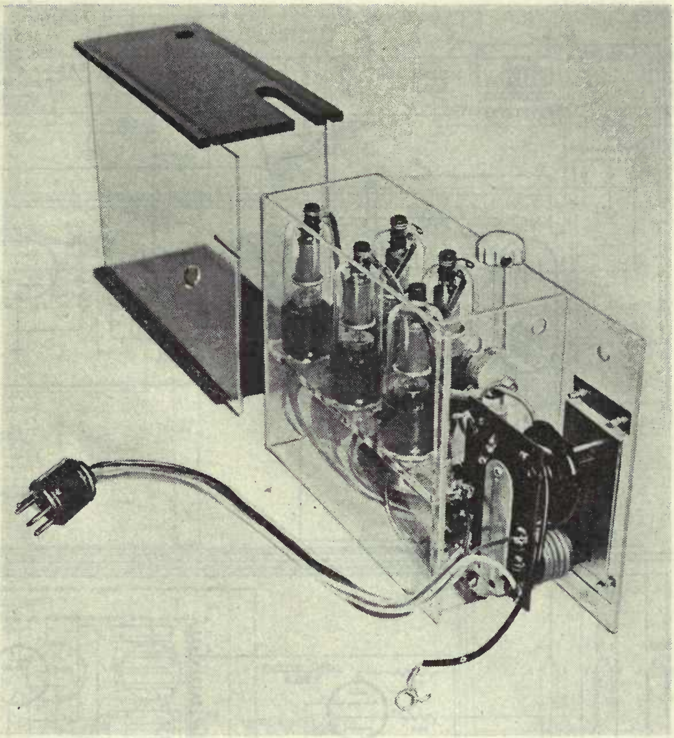


Fig. 8. The tripler assembly, top.

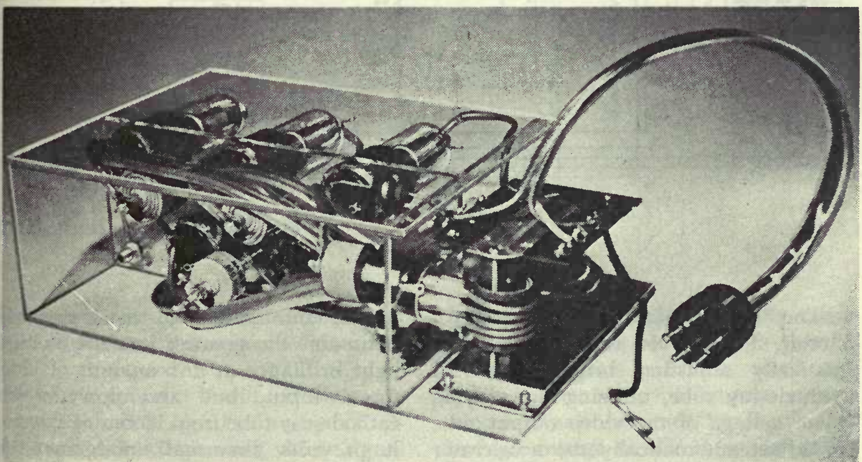


Fig. 9. The tripler assembly, bottom.

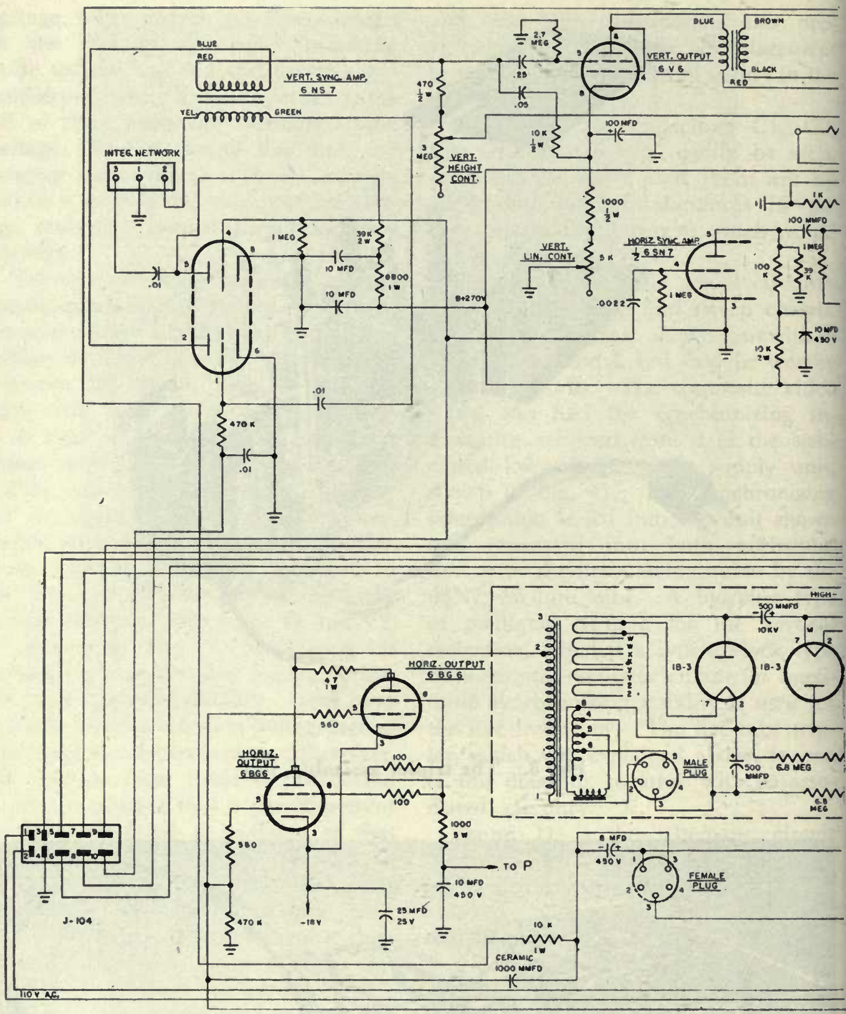
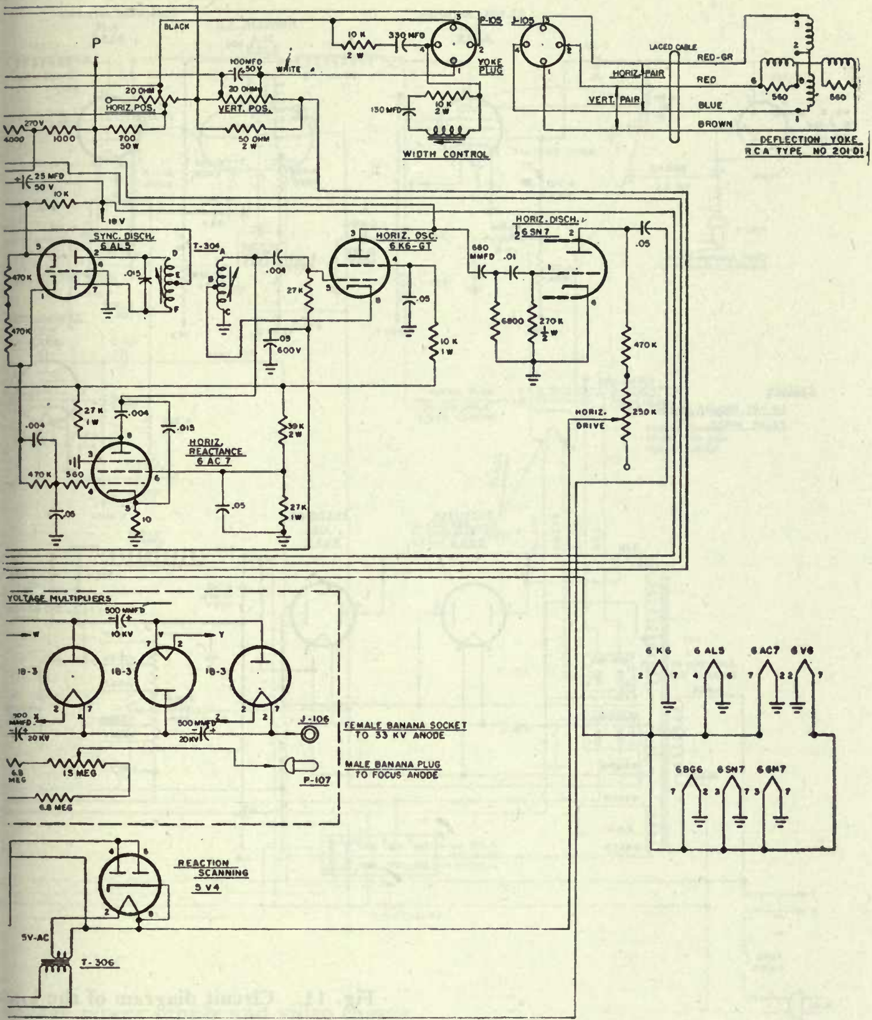


Fig. 10. Circuitry in the high-

The automatic brightness control circuit, Fig. 12, is a means of automatically adjusting brightness on a cathode-ray tube, utilizing the varying plate voltage of the video output tube to adjust automatically the accelerator voltage on the accelerator grid AG of the cathode-ray tube CRT.

This automatic adjustment not only maintains the greatest amount of highlight brilliance at any amount of video signal input, but also prevents the cathode-ray tube from blooming, that is, it prevents abnormal enlargement of picture or raster. This in effect is accomplished by varying the accelerator



voltage and sweep chassis.

voltage upward when the video signal is increased and downward when video signal is decreased.

If the automatic brightness circuit is not used, and a *high fixed voltage* is applied at AG at greatest video signal input, the highlight brightness of the image is high; but upon decreasing the video signal, the brightness of the raster remains the same and the high voltage at HV decreases gradually until the signal is removed. Then the raster "blooms" and becomes "milky," and the high voltage at HV shoots up to its maximum, possibly causing arc-over in the system.

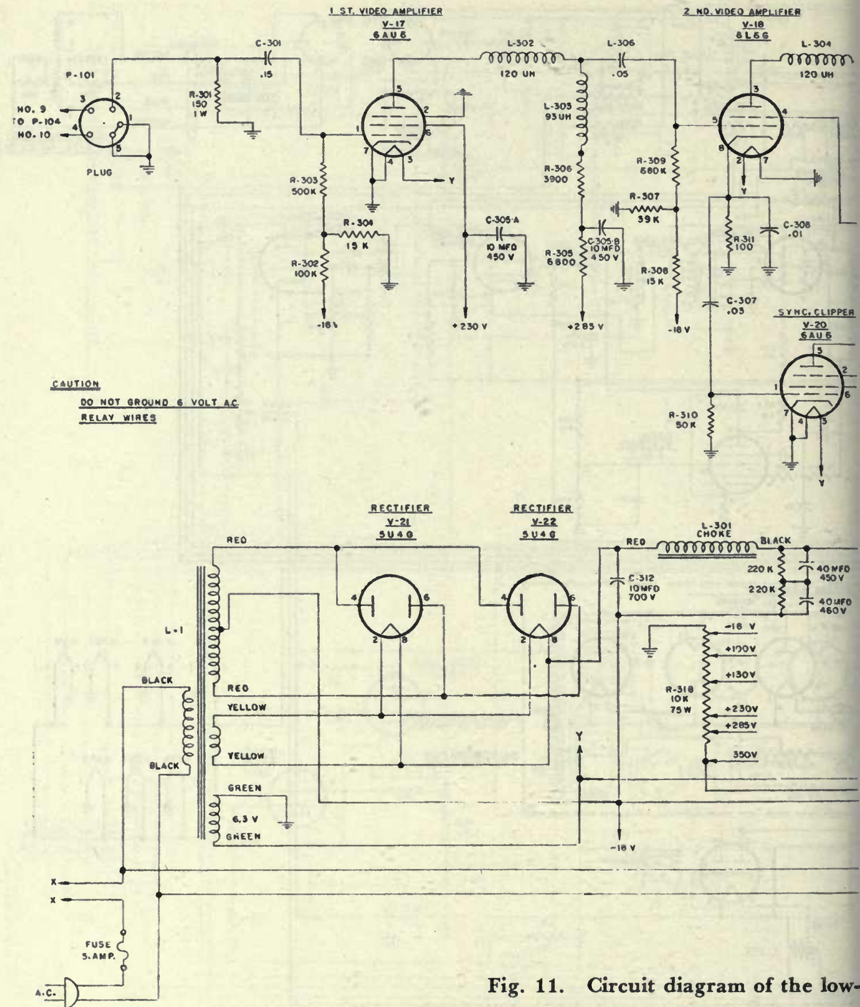
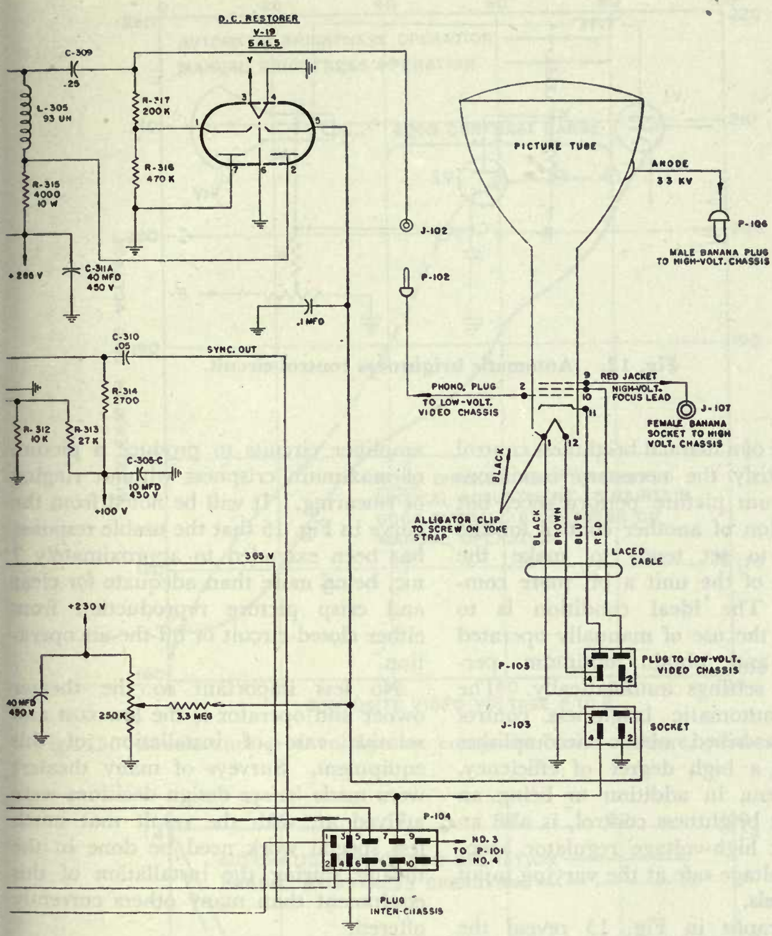


Fig. 11. Circuit diagram of the low-

If, on the other hand, a *low fixed voltage* is applied at AG at the greatest signal input, the highlight brightness is not as high as when the above automatic circuit is used, but the voltage at HV is at a higher point than above. Then, upon decreasing the video signal, the high voltage decreases and the raster brightness remains the same — even after the signal is removed.

From the two conditions described, it is found that, at the high signal input, the picture should be brightest; therefore, the volts at AG should be at a maximum. This keeps voltage at HV at a fixed high-voltage point for greatest possible highlight brightness. As the signal is decreased, the voltage at AG should be decreased, so that the voltage at HV remains very close to its high-



voltage power supply and video chassis.

voltage point, giving the brightest possible picture at this setting. Upon the removal of the signal, the voltage at AG should be brought to its lowest point for proper operation to prevent blooming and the voltage at HV continues to decrease normally — preventing the failures and breakdowns as explained previously. Also, it is readily seen that changing from station to station in this system will cause a decrease of voltage at HV making a very effective safeguard against breakdown.

Potentiometer R, Fig. 12, is a manual adjustment of this proper minimum and is used to compensate for variables in different units which may cause this minimum voltage to be too high, thus causing blooming and the shooting up of the voltage at HV.

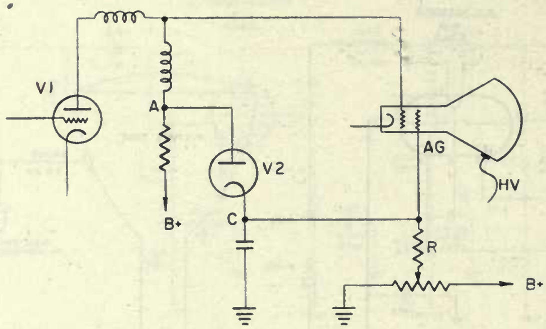


Fig. 12. Automatic brightness control circuit.

The use of a manual brightness control would satisfy the necessary conditions for optimum picture performance, but the addition of another control for the operator to set tends to make the operation of the unit a bit more complicated. The ideal condition is to eliminate the use of manually operated controls and obtain optimum performance settings automatically. The "Trad" automatic brightness control circuit described above accomplishes this with a high degree of efficiency. This system, in addition to being an automatic brightness control, is also an automatic high-voltage regulator keeping the voltage safe at the varying input signal levels.

The graphs in Fig. 13 reveal the action of the automatic brightness control with varying video inputs. Also, shown in Fig. 14 is the interrelationship of average beam current resulting from the effect of the automatic brightness control as the video signal is varied. These graphs were made using a flying-spot scanner picture generator, and varying the output signal voltage, going from no picture, through all the intermediate stages, to a condition of maximum contrast.

One of the important design features of the Trad theater projection television unit is the picture quality, which is the result of critical peaking of the video amplifier circuits to produce a picture of maximum crispness without ringing or smearing. It will be noted from the curve in Fig. 15 that the usable response has been extended to approximately 7 mc, being more than adequate for clear and crisp picture reproduction from either closed-circuit or off-the-air operation.

No less important to the theater owner and operator is the low cost and relative ease of installation of this equipment. Surveys of many theaters were made before design decisions were arrived at, with the result that much less special work need be done in the theater during the installation of this equipment than many others currently offered.

It will be noted, in referring to Fig. 1, that associated dual video amplifier, sweep, and high- and low-voltage supply chassis are installed in a convenient-sized housing which is supported at the fore part of the balcony on a single fabricated bracket which is supplied by Trad. This bracket is mounted by means of bolts through the structural support in the balcony. When mounted in this position, it is out of harm's way and yet is readily accessible for routine maintenance and adjustment.

Figure 16 shows the simplicity of the complete electrical wiring of the system,

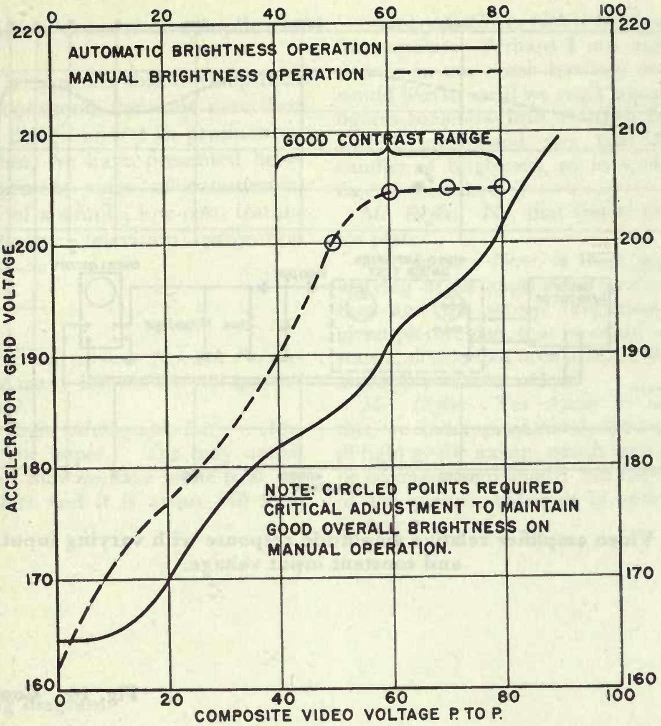


Fig. 13. Accelerator grid voltage vs. composite video voltage, peak to peak.

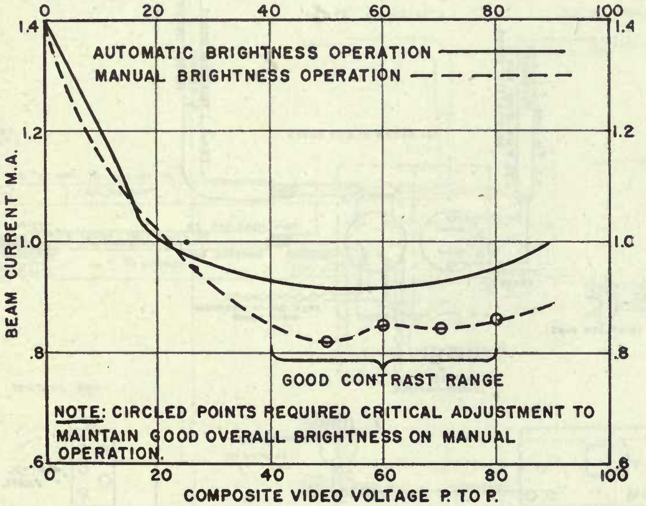


Fig. 14. Average anode beam current vs. composite video voltage, peak to peak.

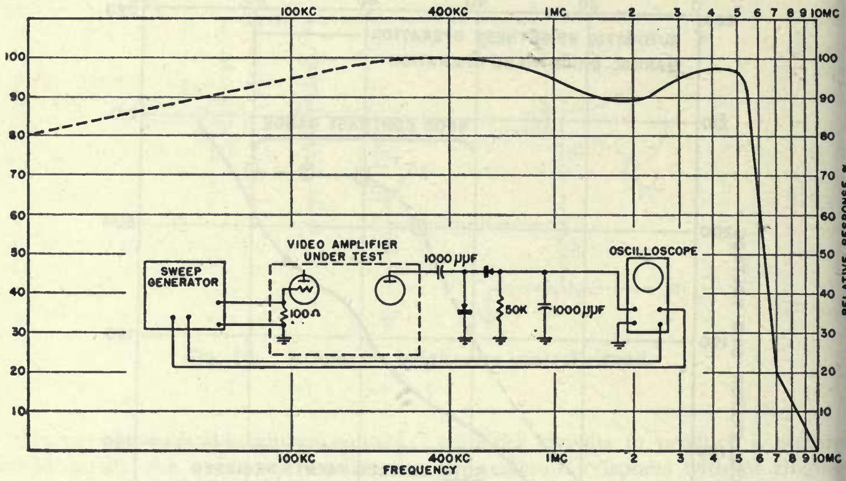
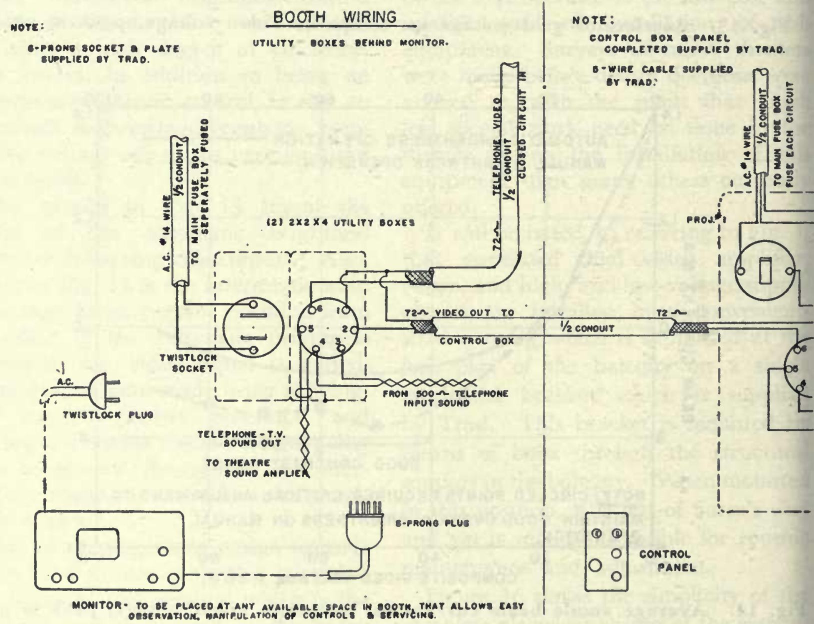


Fig. 15. Video amplifier relative amplitude response with varying input frequency and constant input voltage.

Fig. 16. Complete elec-



necessitating no unusual or complicated wiring.

While it is expected that development work will continue, the unit described is a frozen design and is in production. In conclusion, we have presented herewith the present stage of commercial availability of a simple, low-cost, instantaneous theater television projection system.

Discussion

Robert E. Lewis (*Armour Research Foundation*): How many lumens do you get out of the system?

Frank H. Riffle (*Motiograph, Inc.*): (Mr. Riffle read the paper.) The only actual measurement that we have made is at the corrector plate and it is about 160 foot-candles.

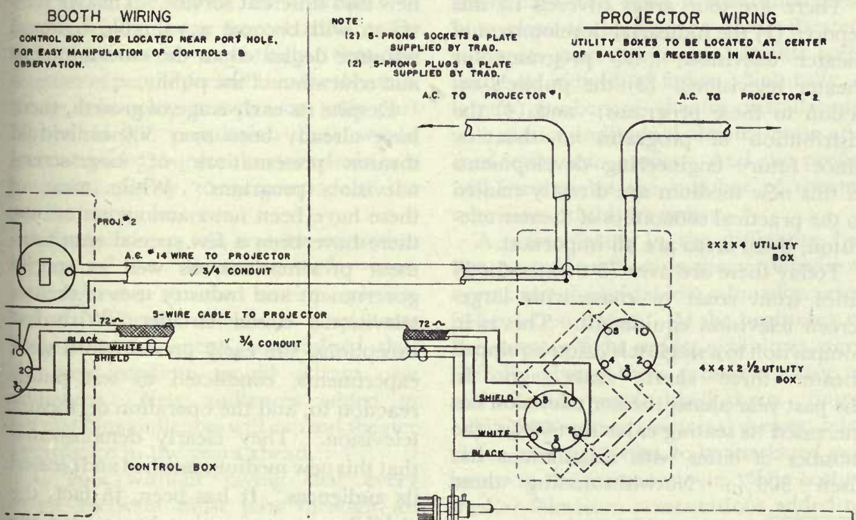
Chauncey L. Greene (*RKO Orpheum Theater, Minneapolis*): Perhaps I am again trying to take in too much territory here, but I would like to see if we can't translate those figures somehow into a screen brightness. Did I understand you that 160 foot-candles of brightness, so to speak, of the face of the tube . . . ?

Mr. Riffle: No, that was at the corrector plate.

Mr. Greene: Now, is there any way of arriving at an approximate ratio between that and the screen brightness for any given picture size, that is, could we, for instance, divide that area into the screen area and apply a factor of loss?

Mr. Riffle: Yes — and in calculating this, we find approximately 0.4 foot-candles of light at the screen, which may appear to be comparatively small; but the brightness of the picture observed is entirely satisfactory.

trical wiring diagram.



Theater Television Progress

By NATHAN L. HALPERN

This is a report on theater television developments in terms of the industry, programs, program distribution and the public interest in this new medium.

In the development of theater television, as in all modern communications media, the engineers have been the pioneers. The records show that as long ago as 1929, technical experiments in large-screen television were being conducted. Many engineers who have been engaged in pioneering this new field, will be interested in hearing of the progress that has been made along trails they blazed.

There are four areas covered in this report: (1) the industrial development of theater television; (2) programs for theater television; (3) the public's reaction to these programs; and (4) the distribution of programs to theaters. Since future engineering developments in this new medium are directly related to the practical economics of theater television, these areas are all important.

Today there are over 75 theaters in 37 cities from coast to coast with large-screen television equipment. This is in comparison to a single television-equipped theater three short years ago. In the past year alone, theater television has increased its seating capacity 600%; the number of cities with installations has risen 300%. Notwithstanding these impressive figures, theater television is only beginning to grow. There are 20,000 theaters to go.

Theater television installations will be made eventually in all motion picture theaters in the country. Although it is off to a fast start, theater television has a long way to go before it can fully realize its great potentials. The harnessing of this form of television by the motion picture industry will offer the public a new and different service. Theater television will become a valuable national resource dedicated to the entertainment and education of the public.

Despite its early stage of growth, there have already been over 300 individual theater presentations of large-screen television programs. While most of these have been news and sports events, there have been a few special entertainment presentations, as well as special government and industry uses of theater television's closed circuits. With few exceptions, the early presentations were experiments, conducted to test public reaction to, and the operation of, theater television. They clearly demonstrated that this new medium satisfied and pleased its audiences. It has been, in fact, the public's acceptance that has caused the further development of theater television.

Theater television has already proved that theater television programs can be

Presented on April 21, 1952, at the Society's Convention at Chicago, Ill., by Nathan L. Halpern, Theatre Network Television, Inc., 515 Madison Ave., New York 22, N.Y.

successful. The conditions necessary for successful special event presentations have been emerging in the past year. Exclusivity, proper promotion and some regularity are all desirable, if not necessary. Matinee sports presentations, which bring new sports audiences into theaters at unprecedented times, require all three of these conditions to be favorable.

The most publicized theater television programs to date were the series of prize fights presented last summer. This series of six fights, presented by Theatre Network Television (TNT), was offered to a public that was unacquainted with the medium, and for this reason the series was presented under adverse circumstances. The boxoffice results were nothing short of startling. The overall average attendance for all theaters on all six TNT fights was 87% of capacity, despite the fact that two of the fights were not top attractions.

This boxoffice average is only a partial indication of the great public interest in these theater television programs. On several of the fights, the numbers of people turned away from boxoffices for lack of seats were much larger than the number of people packed into the theaters. These turn-away crowds were only part of the larger population that would have attended, but for theater television's limited capacity to accommodate the public last summer.

Of importance, too, was the attraction of part of the "lost audience" — non-movie-goers — to the motion picture houses. Theater television proponents had, from the outset, maintained that this new medium would attract new audiences. New audiences added to normal film audiences will expand theater attendance in the years ahead.

It goes without saying that every major medium must pass through an investment period at the start, with operating losses until it has grown sufficiently. The pioneers in home television broadcasting made large-scale investments and sustained high losses for years of operation — losses that ran into millions of dollars for single stations — before they were in the black. The significant thing about theater television is that it has experienced profits on some events from the outset. As compared with television broadcasting, theater television has required relatively small investments and its operating losses have been comparatively small. But before examining the credit side of the ledger, let's take a look at the debits.

The losses incurred in early theater television have not been due to a lack of appeal in its programs or in the medium itself. These relatively small losses were attributable to three factors: (1) the few theaters sustaining the costs of big-time attractions; (2) the pricing policies followed by theatermen; and (3) the absence of a regular, year-round flow of programs and promotion.

Last summer, the TNT series of prize fights was carried by an average of only 12 theaters. In spite of the very small number of theaters which shared relatively high unit costs, it was remarkable how close to break-even these theaters came on most programs. Profits were made on individual fights. Naturally, a larger number of theater installations will reduce individual theater costs and turn losses into profits. And the profits will increase as the number of theater television exhibitors grows.

A prime factor in the difference between profit and loss on theater television events was the initial low admission price policy of exhibitors. At the beginning of the summer fight series, exhibitors were literally giving their products away to see whether people liked them. Some exhibitors seemed to treat theater television as a fight film, to be marketed as a bonus to the feature movie. The cost of theater television presentations added to film exhibition meant exhibitors would incur losses if regular movie admissions were charged. Many chose this course at the start, not realizing that the real

boxoffice pull was theater television, not the movie attraction on such bills. Theaters charged as little as 54¢ net admission for the first several theater televised fights. There was no trouble selling out on nights when film business was ordinarily in the doldrums.

As theatermen saw the public demand and satisfaction, they began to adjust admission prices upward. Moreover, exhibitors began to realize that a theater television event was unique—entirely different from a film which is shown consecutively, or even a live stage show that is repeated throughout its run. A unique, televised event — valuable for the moment — requires special handling and pricing.

By the time of the Robinson-Turpin bout, theaters had adjusted their admission prices to an average well over $2.00. Every theater carrying the fight sold out, evidencing the public's enthusiastic acceptance of this new entertainment medium. The average theater television gross was $5,000 per theater, with seating capacities ranging from 1,100 to 4,000 seats. It became apparent that higher prices for earlier theater television events might have resulted in profits then, too. Moreover, concession sales in theaters boomed, increasing as much as 400% above average.

I would like to give you an idea of theater economics on a successful theater television event at this early period. Perhaps the best way to do this is by taking a specific example: the economics of Theatre X, an actual theater, for one of last summer's TNT fights. Theatre X has 3,300 seats. With a $2.40 gross admission price, and a sellout with 473 standees crammed in, the net receipts, after taxes, were $7,500. Total television costs to the theater (relatively high because of so few theater installations) were $4,000, leaving an operating television profit of $3,500. The deduction of normal house expenses and film distributor costs still left this exhibitor with a whopping profit for a single theater television show. His only regret was that he had to turn away thousands of disappointed people, for lack of room.

The economics of theater television last summer on such individual events clearly pointed up future prospects. If this kind of operating profit could be produced at the outset, with only a handful of theaters, the outlook for programs carried by hundreds and then a thousand or more theaters is fabulous.

The third factor affecting early theater television — the absence of a regular, year-round flow of programs — is due in part to the newness of the medium. The development of entertainment attractions, to go along with outstanding sports events, has preoccupied those of us in theater television these past several months. The entertainment desirable for theater television must, of course, be superior. Even now, theater television is growing closer to the number of outlets necessary to support regularly high-cost presentations and talent.

In the developmental work put into entertainment for theater television recently, talent and craft unions were faced, for the first time, with making decisions on theater television. Most of these unions have recognized the importance of this new field and its gainful employment and compensation potentials for their memberships, as well as its public service aspects. Consequently, their attitudes are becoming progressively more cooperative. Meanwhile, however, time has been consumed in establishing a basis for entertainment in theater television.

It is encouraging to report that there is a wealth of superior talent and entertainment eagerly awaiting the development of theater television. There is no lack of great entertainment, superior to home television and different from movies, for theater television programs. Once the ground rules have been worked out, TNT will launch a schedule of these great programs.

Of paramount importance in limiting the past presentation of theater television

programs has been the unavailability of adequate AT&T facilities to network theaters. The placement of theater television installations necessarily has been made along the routes of the coaxial cable and microwave relay facilities of AT&T. Most theaters in the country cannot be serviced by present telephone company facilities. This situation has forced theater circuits to make multiple installations in fewer cities, thus impeding theater television's early growth. Moreover, the lack of adequate AT&T long lines to theaters located on the cable and relay highways has impaired theater television's ability to develop regular program schedules.

Here is a concrete example of the theater television distribution problem. At the beginning of the year, TNT projected a series of nine programs, to be presented between March 3 and April 13. Considerable work went into the formulation of this series, which included an opera, a Broadway musical, a famous Broadway stage show, a championship fight, championship basketball tournaments, and other sports events. TNT requested AT&T clearances for each program to installed theaters in 23 metropolitan areas at the beginning of February, requiring replies in time for effectuating the schedule.

The total number of long lines clearances for cities requested by TNT of AT&T for these programs was 207; AT&T did not assure clearance of 151; thus 73% of theater television's requirements were not fulfilled for the TNT spring schedule.

The lack of AT&T long lines made this program schedule impractical. Not all theater television requests have met with this fate. However, this experience pointed up acutely that the telephone situation has been a difficult road block to the rapid growth of theater television, and that AT&T has not added sufficient distribution facilities for theater television. The telephone companies have shown increasing understanding of the theater television facilities needs. As a result, it is anticipated that AT&T will free more facilities for theater television, thereby speeding the growth of the medium and increasing its own returns in this field. In this direction, the development of more reasonable telephone charges for theater television should be high on the agenda.

The FCC proceedings on theater television channels will center attention on practical alternatives to these facilities problems. Although postponed in the wake of the hectic activities surrounding the lifting of the television freeze, it is expected that the FCC will reschedule the theater television hearings as soon as possible. Meanwhile, theater television must and will continue to move forward.

Problems on the road to the future are being solved already. Every month the number of theater television installations increases, thus reducing the cost factors for individual theaters. Currently, there are a dozen theater television installations being made, including those of United Paramount Theatres, Warner Brothers Theatres and RKO Theatres. Valuable experience in pricing has been gained already. Programs are being formulated by TNT for production. And it is hopeful that intercity and intracity telephone facilities will become increasingly available at reasonable rates.

Theater television will add fine entertainment of many kinds to its news and sports events. It will provide valuable services in the field of education, as well as specialized closed circuit services to government and industry. It is to be hoped that the growth timetable will not be prolonged by "faint heart" and "Let George do it" attitudes in the industry.

The theater industry needs theater television. The public has already shown that it will go for it. Slowly simmering during the past period, theater television will erupt suddenly with its own formula for success in show business. The road may have obstacles but the future is bright.

Proposed American Standard 16mm Motion Picture Projector for Television

THE INITIAL WORK on this proposal was done by an RMA Subcommittee, TR4.4.2, and a first draft was circulated in May 1950. Need for extensive revision was indicated at the final meeting of TR4.4.2 held in June 1950. At about this time, the present Joint RTMA/SMPTE Committee on Television Film Equipment was organized to replace the RMA Subcommittee.

At the first meeting of the Television Film Equipment Committee, the proposal was again reviewed and revised and a second draft incorporating the desired changes was circulated in September 1950. The extensive nature of the proposal precluded ready agreement, and a third draft, February 1951, and a fourth draft, May 1951, were required before the committee could reach final agreement. The latter was then submitted independently to the RTMA and the SMPTE Standards Committee for further action.

In the RTMA, the proposal TR4-4116 was accepted by TR4, approved for circulation to industry by TREX and released as Standard Proposal #365 in June 1952.

In the SMPTE, the Standards Committee balloted on the question of approving Journal publication of the proposal for a 90-day period of trial and comment and, with but a few exceptions, voted affirmatively. The negative votes were based on the objection that the proposal was more of a procurement or performance specification than a standard defining required dimensional limits for the purpose of aiding interchangeability. With the belief that publication would stimulate worth-while discussion, the Standards Committee gave the necessary approval in June 1952.

Please send comments, in duplicate, to Henry Kogel, Staff Engineer, before December 15, 1952. If no adverse comments are received during the three-month trial period, the proposal will be submitted directly to ASA Sectional Committee PH22 with the recommendation that it be processed as an American Standard.

Proposed American Standard

16mm Motion Picture Projector For Use With Monochrome Television Film Chains Operating on Full-Storage Basis

(Fourth Draft)

PH22.91

1. Scope

1.1 This standard applies only to 16mm motion picture projectors in which the film is advanced intermittently.

1.2 Projectors complying with this standard can be used only with film chains which operate on a full-storage basis.

1.2.1 In full-storage operation illumination from the projector is restricted to the vertical retrace period of the television scan.

1.3 Many of the characteristics of the projector cannot be standardized in specific terms unless the pickup tube used in the film chain is specified. Since the Type 1850-A iconoscope is used almost exclusively at present in film-chain equipment, it has been used as the basis of standardization. If the projector is to be used with any other type of pickup tube, it will be necessary to modify the following paragraphs of this Proposed Standard: 2.1, 2.2, 3.1, 3.2.1, 8.1 and all subparagraphs.

2. Image Dimensions

2.1 An image width of 4½ inches shall be considered standard. (See Paragraph 1.3.)

2.2 The range of focus adjustment shall be sufficient to accommodate widths of image from 3¾ inches to 5 inches. (See Paragraph 1.3.)

2.2.1 The focusing operation shall not displace the picture by more than 1.0% of its width.

3. Projection Lens

3.1 Focal Length. In following sections, for test purposes, the use of a lens having a focal length of approximately 3½ inches will be assumed. (See Paragraph 1.3.)

3.2 Resolution.

3.2.1 Resolution shall be defined and measured in accordance with American Standard Z22.53–1946, except that measurement shall be made with the standard picture width. (See Paragraph 1.3.)

3.2.2 The resolution shall be at least 80 lines per millimeter for the patterns identified as E and D and at least 90 lines per millimeter for all others.

4. Optical Axis

4.1 The projector shall include, or have available as an accessory, a sturdy pedestal. Means shall be provided to place the optical axis (when level) at any required height from 47 to 49 inches from the floor.

4.2 A tilting mechanism shall be included although this need not permit either quick change or change during operation. The range of tilt shall be sufficient to raise or lower by 1 inch an image of standard width, projected by a 3½-inch lens.

4.3 A leveling mechanism capable of rotating the projector about an axis parallel to the optical axis shall be included.

5. Film Gate

5.1 Dimensions. The dimensions of the picture aperture and its location relative to the film shall be in accord with American Standard Z22.8–1950.

5.2 Lateral guiding. At the picture aperture the sprocket hole edge of the film shall be used for lateral guiding. (Note: This is an exception to the recommendations of American Standard Z22.8–1950. For a discussion of the problem involved, see Note 3 of Z22.8.)

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6. Framing Device

6.1 The projector shall have a readily accessible means for positive framing of the picture when the projector is in operation. The range of the framing mechanism shall extend 0.025 inches above and below the standard position measured at the film. The framing device shall be free from creep during operation.

6.2 The method employed for framing shall not change the position of the projected image of the picture aperture by more than 1.0% of the picture width over the full framing range.

7. Picture Stability

7.1 Definition.

7.1.1 The stability of the image depends upon the ability of the projector to locate succeeding frames of film in exactly the same position relative to the picture aperture. Failure to perform this function perfectly results in either jump (vertical instability) or weave (horizontal instability) or both.

7.1.2 Jump and weave shall be measured in terms of the peak-to-peak excursions observed. In each case the result shall be stated as a percentage of picture width.

7.2 Standard.

7.2.1 Jump shall not exceed 0.2% of picture width.

7.2.2 Weave shall not exceed 0.15% of picture width.

7.3 Method of measurement.

7.3.1 Since jump and weave are mechanical characteristics of the projector and are independent of image magnification, it is recommended that both be measured with the greatest magnification that will still give a sufficiently bright image for direct observation.

7.3.2 Jump and weave are usually measured by projecting a Steady Test Film which has an extra perforation in the center of the picture area. This test perforation is made in the same operation in which the sprocket holes are made and it is very precisely located with respect to the sprocket holes. Film of this type may be obtained from the Society of Motion Picture and Television Engineers.

8. Image Illumination

8.1 Intensity. There is no evidence to indicate that any particular significance should be attached either to the peak value of the illumination or to the exact shape of the light pulse as a function of time. Consequently, only the time average value of illumination intensity is standardized. However, in full-storage operation the duration of the light pulse will be approximately 5% of the period of a television field. This short duty cycle is likely to introduce large measurement errors unless certain precautions are observed. (See Paragraph 1.3.)

8.1.1 Definition. The intensity of illumination will be measured in Iconoscope Exposure Units (abbreviated IEU). The IEU is analogous to the foot-candle. Just as foot-candles are measured by a detector having a spectral sensitivity similar to that of the human eye, so are IEU's measured by a detector having a spectral sensitivity similar to that of the Type 1850-A iconoscope. For illumination from a blackbody radiator at a color temperature of 2700 K, a foot-candle

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meter and an IEU meter will give identical readings. (See Paragraph 1.3.)

8.1.2 Standard. The intensity of illumination shall be at least IEU'S.* (See Paragraph 1.3.)

8.1.3 Method of measurement.

8.1.3.1 The intensity of illumination shall be measured in the plane of the standard image with the detector in the central area of the image. (See Paragraph 1.3.)

8.1.3.2 The detector shall have a spectral sensitivity matching as closely as possible the spectral sensitivity of the Type 1850-A iconoscope. A sufficiently close approximation is afforded by a Weston Photronic Cell, Model 594RB, equipped with a Corning filter, Type 5-51, 5562. (See Paragraph 1.3.)

8.1.3.3 The meter used with the Photronic Cell shall have a resistance of 20 ohms or less. Because the illumination pulse is of short duration and high peak intensity, the resistance of the meter will cause errors in measurement which increase rapidly with resistance value. For a 20-ohm movement, the error will not exceed 2% over the anticipated range of intensities with the Weston Model 594RB cell. (See Paragraph 1.3.)

* Field experience relating illumination in IEU's to satisfactory quality is as yet quite limited. It has not yet been possible to determine the number of IEU's which represent the line of demarcation between satisfactory and unsatisfactory performance.

8.1.3.4 The combination of meter and cell shall be calibrated against a foot-candle standard using a blackbody source of illumination at 2700 K. (See Paragraph 1.3.)

8.1.4 The source of illumination shall be operated within any applicable ratings established by the manufacturer of the source.

8.2 Control of Intensity. It is probable that means for varying the intensity of illumination will be required for certain types of pickup tube. However, present information is not sufficent to permit the formulation of a standard.

8.3 Uniformity.

8.3.1 Intensity of illumination at any point in the area of the standard image shall be not less than 80% of the maximum intensity of illumination.

8.3.2 Upon replacement of an incandescent projection lamp, if such is used, no readjustment shall be required to achieve this distribution.

8.3.3 The receptive area of the light-sensitive element used for these readings shall have a diameter not greater than 5% of the picture width. No reading shall be taken with the center of the receptive element closer to the edge of the image area than 5% of the picture width.

8.4 Color. Although color of illumination may have significant effects on picture quality, present knowledge is not sufficient to permit the formation of a standard.

8.5 Flicker. Variation from pulse to pulse of the time integral of the illumination falling on any small area of the image may, under some conditions, give rise to visible flicker in the pic-

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ture from the film chain. However, present knowledge is not sufficient to permit the formulation of a standard.

8.6 Illumination Period.

8.6.1 Definition.

8.6.1.1 The illumination period is the interval of time in which the instantaneous intensity of illumination in any part of the image area exceeds 10% of the peak instantaneous intensity.

8.6.1.2 The length of the illumination period shall be stated in terms of a percentage of V, where V is the time from the start of one television field to the start of the next field.

8.6.2 Standard. The illumination period shall not exceed 5% of V. This value is dictated by the presently accepted minimum value for the vertical blanking period of the television system, which is 5% of V.

8.6.3 Method of measurement. The illumination period shall be measured by means of a photocell, an amplifier, an oscilloscope and a timing oscillator. The photocell and amplifier must respond without saturation to the peak intensity encountered and the frequency response of the combination shall be down not more than 3 db at 50 kc.

9. Pull-Down Period

9.1 Definition. The pull-down period is the interval of time in which film is moving through the picture aperture.

9.2 Standard. The only restriction to be placed on the pull-down period is that it shall never overlap any part of the illumination period.

9.2.1 If, in a particular mechanism, there is any possibility that the pull-down period may vary in phase relative to the illumination period, then the mechanism shall be designed to allow this phase to change by ± 3% of V from the optimum position with no overlap of the two periods.

9.3 Method of measurement. The existence of overlap may be detected by projecting a test subject consisting of sharply defined white objects on a black background, and inspecting the projected picture for evidence of travel ghost. For this test, film complying with the requirements of American Standard Z22.54–1946 is recommended, although many title strips will be found quite satisfactory.

10. Phasing of Projector Relative to TV Vertical Scan

10.1 For the case of a fixed relation between pull-down and illumination periods:

10.1.1 Means shall be provided for setting the illumination period in any desired phase relative to the 60-cycle frequency which controls the phase of the motor.

10.1.2 Each time the projector is turned on, it shall re-establish this preselected phase relation by fully automatic means in less than 3 seconds.

10.1.3 During operation, the preselected phase relation shall be maintained within ± ½% of V.

10.2 For the case of the illumination period locked to the vertical synchronizing signal and independent of the pull-down period, means shall be provided for insuring compliance with Paragraph 9.2 of this Proposed Standard.

NOT APPROVED

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16mm Motion Picture Projector For Use With Monochrome Television Film Chains Operating on Full-Storage Basis

(Fourth Draft)

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11. Film Capacity and Reel Tension

11.1 The projector shall accommodate reels of any capacity from 400 to 3600 feet which comply with the requirements of Proposed American Standard PH 22.11–1952.

11.2 For any reel size in this range, the take-up tension shall at no time be less than 3 ounces nor greater than 10 ounces (hub diameters less than 4.5 inches excepted).

11.3 For any reel size in this range, the braking mechanism on the feed reel shall not cause a tension greater than 3 ounces (hub diameters less than 4.5 inches excepted).

12. Film Life

12.1 After 100 passages through the projector mechanism, film shall exhibit no evidence of damage either visible in the projected picture or audible in the reproduced sound signal.

12.2 In order that a loop of film may be used in this test, renewal of the splice as many times as may be necessary is permitted.

12.3 The film used in this test may and should be carefully selected and lubricated. The projector is not required to pass this test with film which is in inferior condition.

12.4 Passage of a splice in good condition through the mechanism shall not cause serious disturbance, such as loss of loop, nor shall the mechanism cause excessive damage to the splice.

13. Starting Time

13.1 Definition. The interval between applications of power and the attainment of: (a) synchronous operation of the motor and (b) a flutter content in the sound output which is less than the maximum specified in Paragraph 17.2.

13.2 Standard. The starting time shall not exceed 5 seconds.

14. Film Speed

14.1 The nominal speed of projection shall be 24 frames per second. This shall not be interpreted as excluding the use of a 3-2 mechanism.

15. Stopping Distance

15.1 Definition. The length of film that passes through the film gate after removal of power.

15.2 Standard. The stopping distance shall not exceed 3 feet.

16. Manual Drive

16.1 Some readily accessible means shall be provided for slow-speed manual operation of the mechanism as a check on threading, etc.

17. Sound Scanning System

17.1 Synchronization. The film path distance measured in the direction of travel from the center of the picture aperture to the point to which sound scanning occurs shall be 26 frames ± ½ frame.

17.2 Mechanical stabilization. The rms value of the total (sum of all frequencies) flutter shall not be greater than 0.25% when using a 3000-cycle flutter test film complying with the requirements of American Standard Z22.43–1946. Film splices shall not cause any serious disturbance in sound stabilization.

17.3 Dimensions of Scanning Aperture. In the plane of optimum focus the scanning light beam shall have a maximum width of 0.0005 inches and a length of 0.071 ± 0.001 inches. (Reference for length: American Standard Z22.41–1946.)

NOT APPROVED

17.4 Adjustment of Scanning Beam.

17.4.1 Lateral Adjustment. Means shall be provided for adjusting the lateral position of the scanning beam such that the projector does not reproduce either signal on a buzz-track test film complying with the requirements of American Standard Z22.57–1947.

17.4.2 Azimuth Adjustment.

17.4.2.1 Means shall be provided for adjusting the azimuth of the scanning beam.

17.4.2.2 The azimuth shall be adjusted to secure maximum response using a 7000-cycle test film complying with the requirements of American Standard Z22.42–1946.

17.4.3 Focus Adjustment.

17.4.3.1 Means shall be provided for adjusting the focus of the sound optics to place the plane of optimum focus in coincidence with the emulsion plane.

17.4.3.2 Focus shall be adjusted to secure maximum response using a test film complying with the requirements of American Standard Z22.42–1946.

17.4.3.3 Means shall be provided for rapidly and accurately shifting the plane of optimum focus to coincide with the emulsion position on either side of the film.

17.5 Light Distribution. The light distribution in the scanning aperture shall be sufficiently uniform to produce a signal across a resistive load at the output of the preamplifier which is constant within ± 1.5 db when reproducing a Scanning Beam Uniformity Test Film complying with the requirements of American Standard Z22.80–1950 or Z22.81–1950.

17.6 Exciter Lamp.

17.6.1 The exciter lamp shall be so mounted as to permit rapid replacement.

17.6.2 It is not desirable that uniformity of illumination in the scanning aperture be critically dependent upon exciter lamp position. If this condition exists, means shall be provided for independent horizontal and vertical adjustment of the exciter lamp position.

17.6.3 The exciter lamp shall be a prefocused type unless the lamp holder is a replaceable type equipped with adequate adjustments which can be preset, and a spare lamp holder is provided.

17.6.4 The exciter lamp shall be operated at all times within any applicable ratings established by the manufacturer of the lamp.

18. Sound Amplification System

Any statement of sound-reproduction characteristics must necessarily cover the performance of a preamplifier which is specifically designed as a component of the projector. However, it is not essential that all or even any part of the preamplifier be included in the projector structure. Wherever they are mounted, all parts of the preamplifier should be readily accessible.

18.1 Output Impedance. There shall be available output impedances of 600 and 150 ohms, both to be balanced outputs.

NOT APPROVED

Proposed American Standard 16mm Motion Picture Projector For Use With Monochrome Television Film Chains Operating on Full-Storage Basis (Fourth Draft)	PH22.91

18.2 Output Level.

18.2.1 Standard. The output level shall be —10 dbm.

18.2.2 Method of measurement. This level shall be produced using level test film complying with the requirements of American Standard Z22.45–1946.

18.2.3 A gain normalization control shall be provided having sufficient range to insure compliance with the above standard for any normal combination of exciter lamp, photocell and amplifier tubes.

18.3 Frequency Response.

18.3.1 If the frequency response from film to output is fixed, it shall be flat within ± 1 db from 50 to 6000 cycles per second. If tone controls are provided in the preamplifier, their range of adjustment shall include this response.

18.3.2 Method of measurement. The frequency response shall be determined by means of a multifrequency test film complying with American Standard Z22.44–1946. The amplitude of response shall be measured across a resistance load at the output of the preamplifier. The frequency response shall be determined with standard gain. (See Paragraph 18.2.)

18.4 Distortion. Although it is desirable to state a distortion standard which will cover the photocell as well as the preamplifier, a method of measurement which will accomplish this result is not known. Consequently, the present Standard Proposal covers only distortion in the preamplifier.

18.4.1 Standard. Total harmonic distortion in the preamplifier at standard output level shall not exceed ½% in the range from 50 to 6000 cycles per second.

18.4.2 Method of Measurement. Test signals from an oscillator shall be applied at the photocell input of the preamplifier and distortion shall be measured with a distortion analyzer at the preamplifier output at standard output level.

18.5 Preamplifier Noise Level.

18.5.1 Standard. The noise level of the preamplifier shall be —65 dbm.

18.5.2 Method of measurement. The noise level of the preamplifier shall be measured at standard gain (see Paragraph 18.2), with the projector running, the exciter lamp energized and no light entering the photocell.

18.6 Overall Noise Level.

18.6.1 Standard. The overall noise level shall be —55 dbm.

18.6.2 Method of Measurement. The overall noise level shall be measured at standard gain (see Paragraph 18.2), with the projector running, the exciter lamp energized and no film in the machine.

Appendix A

The gate of the projector should be designed to provide easy access to aperture and rails for thorough and effective cleaning and inspection.

NOT APPROVED

Proposed American Standard

16mm Motion Picture Projector For Use With Monochrome Television Film Chains Operating on Full-Storage Basis

(Fourth Draft)

PH22.91

Appendix B

The American Standards listed below have been cited in the present Proposed Standard. Copies of any of the reference standards may be obtained from the American Standards Association, 70 East 45 Street, New York 17, New York.

1. Z22.8–1950
   Location and Size of Picture Aperture of 16mm Motion Picture Projectors.
2. PH22.11–1952
   16mm Motion Picture Projection Reels.
3. PH22.16
   Emulsion and Sound Record Positions in Projector for Direct Front Projection of 16mm Sound Motion Picture Film.
4. Z22.41–1946
   Sound Records and Scanning Area of 16mm Sound Motion Picture Prints.
5. Z22.42–1946
   Sound-Focusing Test Films for 16mm Sound Motion Picture Projection Equipment.
6. Z22.43–1946
   3000-Cycle Flutter Test Film for 16mm Sound Motion Picture Projectors.
7. Z22.44–1946
   Multi-Frequency Test Film for Field Testing 16mm Sound Motion Picture Projection Equipment.
8. Z22.45–1946
   400-Cycle Signal Level Test Film for 16mm Sound Motion Picture Projection Equipment.
9. Z22.53–1946
   Method of Determining Resolving Power of 16mm Motion Picture Projection Lenses.
10. Z22.54–1946
    Freedom from Travel Ghost in 16mm Motion Picture Sound Reproducers.
11. Z22.57–1947
    Buzz-Track Test Film for 16mm Motion Picture Sound Reproducers.
12. Z22.80–1950
    Scanning-Beam Uniformity Test Film for 16mm Motion Picture Sound Reproducers (Laboratory Type).
13. Z22.81–1950
    Scanning-Beam Uniformity Test Film for 16mm Motion Picture Sound Reproducers (Service Type).

NOT APPROVED

Proposed Amendments to the Bylaws

Two suggested amendments to the Bylaws of the Society are presented here, with the Board of Governors' reasons for proposing that they be adopted. They represent the first formal result of an official study of organization and operating practices of SMPTE started last January at the Board's request and are intended to state clearly two matters of importance. The first recites the long established policy of the Society respecting the voluntary nature of Standards and Recommendations developed within SMPTE engineering committees. The second sets down, of legal necessity, a newly drawn provision for disposition of the Society's assets in the unlikely event of dissolution.

For these amendments to become official they must be processed as outlined in Bylaw XIII last published on page 348 of the *Journal* for April this year. The Board of Governors initiated the recommendation during its meeting in New York on July 17. Publication here is also required and next comes consideration by the voting members during the regular meeting of the Society which is held annually during the fall convention. This year it will occur at 3 P.M. Monday afternoon, October 6, just preceding the first technical session of the Society's 72d Convention at the Hotel Statler in Washington, D.C.

Voluntary Standards

As a part of his regular quarterly report to the Board of Governors, Fred T. Bowditch, Engineering Vice-President, stated his belief that although the members of the Society knew that American Standards for which the Society serves as sponsor, and other formal Recommendations published by the Society, were voluntary, and that their existence did not preclude members or nonmembers from manufacturing and selling products not conforming to the Standards, it would be advisable to incorporate a provision to that effect in the Bylaws of the Society. The Board was in agreement and passed a Resolution proposing adoption of the following:

BYLAW XIV

Standards and Recommendations

Sec. 1. American Standards sponsored by the Society and the Society's Recommendations are proposed and adopted in the public interest and are designed to eliminate misunderstanding between the manufacturer and the purchaser and to assist the purchaser in selecting and obtaining the proper product for its particular need. Existence of such a Standard or Recommendation does not in any respect preclude any member or nonmember from manufacturing or selling products not conforming to the Standard or Recommendation.

Disposition of Assets

Herbert Barnett, Executive Vice-President, who served as Chairman in the absence of President Peter Mole, stated that in his opinion it would be advisable to provide in the Bylaws for disposition of the Society's assets in case of dissolution. After extended discussion, the Board voted in favor of such a provision, approving unanimously the following proposed amendment:

BYLAW XV

Disposition of Assets and Dissolution

Sec. 1. Upon the dissolution of the Society and after payment of all indebtedness of the Society, the funds, investments and other assets of the Society shall be given and transferred to some other nonprofit organization having objects similar to those of the Society. The selection of such other organization shall be made by the Board of Governors either at a regular meeting of said Board of Governors or at a special meeting of said Board called for the purpose of selecting such an organization.

72d Semiannual Convention

This Fall's Convention at the Hotel Statler, Washington, D.C., October 6–10, will be a blaze of highlights with very strong base lighting of the fields of Society interest, for despite the heat, humidity, politics and other summer distractions all the plans keep building.

Program Chairman Joe Aiken has lined up the scores of papers into some 14 sessions to release the Advance Notice of the Convention to be mailed to all members in the Western Hemisphere on August 6. This carries the tear-off postal for reserving hotel rooms. If you have not made reservations and need a copy of the postal for convenience, ask Society headquarters for one. The Advance Notice also has the abstract of the technical papers sessions.

Although the sessions are all arranged, occasionally authors have to withdraw a paper—so if you have a special paper suddenly cleared, it might still be fitted into the Final Program. If so, write air mail or wire: Joseph E. Aiken, 116 N. Galveston St., Arlington, Va.

One large and special part of the technical program will be the first International Symposium on High-Speed Photography which is planned as fully the equivalent of two days of sessions, some of them concurrent with sessions on topics from other parts of the Society's interest. John H. Waddel is Chairman for this symposium.

16mm equipment maintenance is the subject of another session being developed by R. T. Van Niman who will welcome all who come bearing manuscripts, ideas or possibly other contributions to this symposium and discussion.

A session on magnetic striping has been organized by Glenn Dimmick. This session contains four formal papers but there is still allowable room for anyone who feels that he can or should make a contribution to this subject.

Highlights that can now be mentioned are: descriptions of recording television pictures on magnetic tape presentation of the Signal Corps' Mobile Television System; report on the National Television Systems Committee accomplishments in color television; laboratory session papers on high-speed processing, rapid drying, and butt-weld splicing.

Bill Kunzmann, the Society's Convention Vice-President, gave the Board of Governors a complete report in July, covering all the arrangements and commitments made for the Washington convention. Bill was in Washington in late May and at that time held an organizational meeting which resulted in our having the following roster of folks who will put over the operation of the convention:

Program Chairman — Joseph E. Aiken
International Symposium on High-Speed Photography — John H. Waddell
Papers Committee — Chairman, Edward S. Seeley — Vice-Chairmen, Joseph E. Aiken, Fred G. Albin, Geo. W. Colburn, Gerald G. Graham, W. H. Rivers and John H. Waddell
Local Arrangements — Joseph E. Aiken
Hotel Reservations and Transportation — Henry Fisher
Luncheon and Banquet — Nathan D. Golden
Membership and Subscriptions — Ray Gallo, assisted by G. J. Badgley
Motion Pictures — James Frank, Jr., assisted by John V. Waller
Naval Ordnance Laboratory Session Arrangements — Max Beard
Projection, 35mm and 16mm — Carl R. Markwith and Henry F. Heidegger, assisted by John V. Waller, and members Local 224, I.A.T.S.E.
Public Address and Recording — J. Clinton Greenfield
Publicity — Harold Desfor, assisted by Leonard Bidwell and J. A. Moses
Registration and Information — Keith B. Lewis, assisted by P. M. Cowett, Fred W. Garretson, Max Kerr, J. A. Moses and Howland Pike
Television — Col. C. S. Stodter, R. N. Harmon and W. P. Dutton
Ladies Reception and Registration — Mrs. N. D. Golden and Mrs. J. E. Aiken, Cohostesses

Engineering Activities

Development of American Standards

Motion picture — and related television — standards in the United States are today developed primarily by SMPTE Engineering Committees. While that is widespread knowledge, the steps in that development are probably not so well known. A brief review of the procedures used in producing American Standards in cinematography is therefore given below. It is hoped that an awareness of these procedures will make for an even wider participation in standards activity, which can only serve to improve the quality and observance of these standards.

1. **Request for Standard:** The need for a standard may be brought to the attention of the Society's Engineering Vice-President by anyone interested: manufacturer, consumer, Society member, government body, etc.

2. **Drafting the Standard:** The Engineering Vice-President estimates the general value of the request and refers the project to the appropriate Engineering Committee. The Committee, a broad representative group of some phase of the motion picture industry, makes any required studies or surveys and prepares a draft standard.

3. **Reviewing the Standard:** After the Engineering Committee approves its "final" draft, the proposed standard goes through an extensive review to assure the kind of acceptance required under our system of voluntary standards.

a. Standards Committee: The SMPTE Standards Committee is composed, in the main, of the chairmen of the engineering committees. This first review of the proposal is therefore designed to achieve agreement within the Society. Approval by the Standards Committee is required before the draft can be published in the *Journal.*

b. Journal Publication: Publication of the draft for some stated period (usually 3 months) for trial and comment provides all *Journal* readers an opportunity to study and criticize the proposal.

c. ASA Sectional Committee, PH22: If no adverse comments have been received during the trial period, the Engineering Vice-President transmits the proposed standard to PH22 with a recommendation that it be processed as an American Standard. PH22 is composed of representatives from every group having a vital interest in cinematographic standards. Approval by PH22 generally indicates that the technical content of the standard is in good order.

d. SMPTE Board of Governors: After approval, PH22 returns the standard to the Society for sponsor approval which is conferred by Board of Governors action.

e. Photographic Standards Correlating Committee: At this point and on behalf of the Board of Governors, the Executive Secretary formally transmits the proposed standard to the Director of the ASA, concluding Society action on that particular standard. The Correlating Committee is an ASA body formed to integrate the standards activity of all elements of the photographic industry and so reviews all photographic standards proposals before final approval is granted.

4. **American Standard:** A proposed standard acquires the stamp "American Standard" upon approval of the ASA Standards Council, the final board of review. This group has representatives from each ASA Member Body and thus provides a clearing house for vast numbers of standards from widely diversified industries. Publication in the SMPTE *Journal* completes the lengthy journey from request to American Standard.

It should be noted that any group may submit a proposed standard to PH22 for processing as an American Standard and this the Motion Picture Research Council has done in quite a few instances. This in no way changes the ensuing procedure since the SMPTE as sponsor of PH22 must review the proposal in order to authorize the required sponsor approval.

Your attention is also drawn to the fact that the technical committees of the Society are not closed corporations. A request to have your organization represented on one or several engineering committees would be welcomed by the Engineering Vice-President and would receive serious consideration — *Henry Kogel*, Staff Engineer.

Canadian Standards Association

The Canadian Standards Association was established by Dominion charter granted in 1919. As a result of experience gained during several years of operation and particularly during the war years the charter was amended in 1944 to embrace a broader field of operation as outlined below:

(a) To provide, originate and furnish Canadian standards of any nature whatsoever which are in the interests of producers and users; to coordinate the efforts of producers and users toward the improvement and standardization of materials, processes and related matters; to provide systematic means by which organizations interested in standardization work may cooperate in establishing and promoting Canadian standards to the end that duplication of work and the promulgation of conflicting standards may be avoided.

(b) To serve as a clearing house for information on standardization work in Canada and foreign countries; to further the standardization movement as a means of advancing the national economy, and to promote a knowledge of, and the use of, approved Canadian standards both in Canada and foreign countries; to act as an authoritative Canadian channel in international cooperation in standardization work.

(c) To register in the name of the Association, and to hold, own, use and operate any and all trade marks, proof, letter or device and to enforce and protect the use of such marks, proofs, letters or devices and to oppose any proceedings or applications which may seem calculated directly or indirectly to prejudice the interests of the Association.

Committee Organization

The Canadian Standards Association has close contact, by direct representation, with the following classifications of interest: Manufacturers, Departments of the Dominion Government, Provincial Governments, Public Utilities, Educational Institutions, Professional Bodies, Labour Organizations, Purchasing Departments, Insurance Interests.

From the various classifications of interest a series of Divisions has been established covering such representative fields as Textiles, Agriculture, Pulp and Paper, Steel Construction, Electrical Engineering, etc. From these Divisions a Main Committee is drawn, each member serving for a period of three years and eligible for further service at the discretion of the nominating interests. This is the governing body of the C.S.A.

From the Main Committee, members are elected by the Divisions to form the Executive Committee which is the administrative body of the Association.

Sectional committees are appointed by the Divisions, each sectional committee consisting of from 10 to 30 members, representing the best available knowledge and experience in their respective fields. Their responsibility is to supervise the work of standardization with the scope of each division. They are responsible for the approval of specifications, which have been developed by their working committees and for submitting same to the Executive Committee for final approval and publication.

When a request is received to produce a standard specification for any commodity, it is referred to the division interested, for consideration and recommendation to the Executive Committee for action. Should there appear to be a reasonable demand for the standard in question and sufficient information available to assure satisfactory completion of the work, authority will be given to the division by the Executive Committee to proceed with the preparation of a standard.

If sufficient information appears to be lacking, and scientific investigation is considered necessary, proposals will be made to a recognized research body, such as the National Research Council, to conduct tests or make investigations in order to provide needed information that will permit an authoritative standard to be prepared.

These Working Committees consist of a variable number of members ranging from five or six to as high as thirty or more, depending on the nature of the work to be done.

As work progresses, a draft specification is prepared and subsequently discussed

at meetings of the Working Committee. Verbal recommendations for revision, and those received from members unable to attend or interests not desiring direct representation, receive full consideration. This usually necessitates the preparation of several draft specifications, requiring considerable time before a proposed standard is considered ready for publication.

Every effort is made, not only to assure full representation of the views of all interests, but to tap every available source of information, both foreign and domestic. Accordingly, when a standard is published, it represents, as far as possible, the best available authority consistent with general knowledge and local conditions.

Approvals Division

The C.S.A. has had a certification procedure in effect for many years and the C.S.A. label is recognized throughout Canada as a symbol of assurance that electrical equipment and devices are reasonably free from fire and accident hazards. This Approval Service, which now insures compliance with safety and performance standards can be extended, as and when industry becomes convinced that certification, on a quality basis, is beneficial to the producer as well as to the consumer. The details of the procedure will be developed in collaboration with appropriate producer and consumer interests as required.

C.S.A. Standards

An important feature of C.S.A. standards, in line with British and American standardizing practice, is that they are "voluntary" standards. As such, they serve as recommendations to industry and may or may not be adhered to by the manufacturers concerned.

Such standards may, on the other hand, become mandatory by adoption by a government department having legal authority to enforce their requirements in the matters of governmental purchases, when the standards concern specific materials or products. The Association has published approximately 200 such standards — thus far limited to the various sections of engineering.

Photography

The C.S.A. Sectional Committee on Photography was organized in 1948 with Dr. L. E. Howlett of the National Research Council as chairman. Three specification committees are at work in this field at the present time:

Z7.1 — Motion Picture Photography;
Z7.2 — Still Photography; and
Z7.3 — Survey Photography.

Committee Z7.1 has completed a review of all basic A.S.A. and B.S.I. motion picture standards and some 43 have been published by the C.S.A. A specification for an industrial and educational model 16mm projector is now in the final draft stage. Members of this committee with their affiliations are:

A. H. Simmons (*Secretary*), Gevaert (Canada) Limited, Ottawa
Harold Walker, Dominion Sound Equipments Limited, Montreal
Don Spring, Canadian Kodak Sales Ltd., Toronto
John Gerald, Ansco of Canada Ltd., Toronto
Sqn. Ldr. N. Drolet, Armed Services, Ottawa
Gordon Adamson, National Film Society, Ottawa
Gaudry DeLisle, Department of Education, Quebec City
H. Goldin, Consulting Engineer, Toronto
M. Metzger, Associated Screen News Ltd., Montreal
Arthur Elsey, Canadian Industries Ltd., Montreal
P. D. Carmen, National Research Council, Ottawa
A. J. Pauley, The Odeon Theatres (Canada) Ltd., Toronto
F. T. Myles, R.C.A. Victor Co. Ltd., Montreal
John Young, Benograph, Montreal
G. Graham (*Chairman*), National Film Board, Ottawa

Editor's Note: This report was kindly prepared by Gerry Graham, Director of Technical Operations, National Film Board of Canada, upon our request for help in adding to the series of brief articles describing organizations which SMPTE members wish to know more about. Previous stories have been about the American Documentation Institute, the Biological Photographic Association, and the University Film Producers Association. Your suggestions for subjects or possible contributors for other articles are welcome.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 Membership Directory.

Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

Baggs, Sgt. David A., Officer in Charge of Motion Picture Processing, U.S. Air Force. **Mail:** 2413 Girard Pl., N.E., Washington 18, D.C. (A)

Barr, William J., Camera Technician, Warner Bros. **Mail:** 5537 Costello Ave., Van Nuys, Calif. (A)

Benedict, Joel A., Director, Bureau of Audio-Visual Aids, Arizona State College. **Mail:** 929 McAllister, Tempe, Ariz. (M)

Beyer, Walter, Motion Picture Engineer, Bell & Howell Co. **Mail:** 7455 N. Greenview Ave., Chicago 26, Ill. (A)

Board, Cornelius Z., Arizona State College. **Mail:** Route 1, Scottsdale, Ariz. (S)

Bonner, Ray S., Recording Engineer, Gallagher Films, Inc. **Mail:** 5062 N. 54 St., Milwaukee, Wis. (A)

Cackowski, John, University of California. **Mail:** 5324 Monroe St., Los Angeles 38, Calif. (S)

Chaffee, William H., President, Model Builders, Inc., 5300 W. 63 St., Chicago 38, Ill. (M)

Clark, Dick H., Student and Teaching Assistant, University of California, Motion Picture Dept., 405 Hilgard, Los Angeles, Calif. (A)

Cooper, Richard J. G., Technical Officer, Dept. of National Defense, No. 11 Supply Depot, R.C.A.F., Calgary, Alberta, Canada. (A)

Copeman, Robert A., Motion Picture Service Engineer, Box 2140, Salisbury, Southern Rhodesia. (A)

Curran, Charles W., Motion Picture Producer, Times Square Productions, Inc. **Mail:** 145 W. 45 St., New York 36, N.Y. (M)

Damm, Roger, American Television Institute. **Mail:** 7408 Warren Ave., Forest Park, Ill. (S)

Donovan, Lewis N., Chief Radio Operator, Alberta Government, Dept. of Lands & Forests. **Mail:** 10028—105 St., Edmonton, Alberta, Canada. (A)

Dunn, Reginald S., Laboratory Technician, Color Reproduction Co. **Mail:** 4841 Stansbury Ave., Sherman Oaks, Calif. (A)

Edwards, Marvin J., Arizona State College. **Mail:** 6225 N. 47 Ave., Glendale, Ariz. (S)

Fernandez, Victor M., National Airlines, Inc. **Mail:** 13 y Ave. Primera, Ampl. de Almendares, Havana, Cuba. (A)

Gerard, Morton T., Jr., Motion Picture Photographer, North American Aviation, Inc. **Mail:** 2457 Ashland Ave., Santa Monica, Calif. (A)

Gilkeson, David C., Project Engineer (Optics), Wollensak Optical Co., 850 Hudson Ave., Rochester 21, N.Y. (M)

Hall, Carlisle D., Laboratory Manager, Ansco. **Mail:** 5506 N. Winthrop Ave., Chicago 40, Ill. (M)

Herzig, Leonard A., President, Sound Engineer, Prestoseal Manufacturing Corp. **Mail:** 87–11—35 Ave., Jackson Heights, N.Y. (M)

Hine, Sheldon, Technical and Engineering Photography, 2538 Joan St., Fort Wayne, Ind. (A)

Holblinger, Anton, Sound Engineer, Photo-Magnetic Sound Studio, Inc. **Mail:** 35 Princeton St., Valley Stream, L.I., N.Y. (M)

Jennings, Forrest, Laboratory Technician, Color Reproduction Co. **Mail:** 2363 Hermits Glen, Hollywood 46, Calif. (A)

Johnson, Culver, Engineer, Culver Johnson Research, 871 Seventh Ave., New York, N.Y. (M)

Jones, Almon, U.S. Naval Photographic Center. **Mail:** 3130 Knox St., S.E., Washington, D.C. (A)

Klein, Gerard, New York University. **Mail:** 205 Beach 81 St., Rockaway Beach, N.Y. (S)

Marcus, Wil, Motion Picture Producer, Loucks & Norling Studios, 245 W. 55 St., New York 19, N.Y. (M)

Meunier, Jean L., President, Institut Teccart, Inc., 3155 Hochelaga St., Montreal 4, Canada. (A)

Mikrut, Stanley M., Motion Picture Laboratory Technician, Coronet Films. **Mail:** 2460 Winona St., Chicago 25, Ill. (A)

Mims, Charles W., Mechanical Engineer, Technicolor Motion Picture Corp. **Mail:** 124¼ N. Parkview St., Los Angeles 26, Calif. (A)

Reiche, Ludwig P., Electrical Engineer, International Telemeter Corp. **Mail:** 1445 Miller Way, Hollywood 46, Calif. (M)

Rocha, Gustavo Humberto E., Head, Sound Service and Installation Dept., Casa Ehlers. **Mail:** Abraham Gonzalez #4, Mexico City, Mexico. (A)
Scherlis, William, Cameraman, 241 U. S. Grant Hotel, San Diego 15, Calif. (A)
Schulman, Marvin, Television Engineer, KPIX, Inc. **Mail:** 175 Buckingham Way, Apt. 1A, San Francisco 27, Calif. (A)
Simpson, Richard L., Motion Picture Projection Equipment Mechanic, Naval Photographic Center. **Mail:** 3716 Second St., S.E., Washington 20, D.C. (A)
Steel, Lt. Col. W. Arthur, Radio Engineer, Federal Electric Manufacturing Co. **Mail:** 4737 Grosvenor Ave., Montreal, P.Q., Canada. (M)
Theiss, Sylvester E., Technical Writer (Electronics), U.S. Government. **Mail:** 310 Audrey La., S.E., Washington 20, D.C. (M)
Tunnell, George W., Product Administration, RCA Broadcast Section. **Mail:** 222 W. Plumstead Ave., Lansdowne, Pa. (M)
Vaughan, Leslie D., Photographer, State Geological Survey, 404 Natural Resources Bldg., Urbana, Ill. (A)
Wallace, Charles A., Arizona State College. **Mail:** 600 E. Second, Roswell, N.M. (S)
Winkler, Ben, Sound Mixer, Radio Corporation of America. **Mail:** 11209 Emlita St., North Hollywood, Calif. (A)
Wolfe, Benjamin, Television Broadcast Engineer, WAAM-TV. **Mail:** 3513 Lucille Ave., Baltimore 15, Md. (A)
Worley, E. Max, Motion Picture Technician, Color Reproduction Co. **Mail:** 10552 Putney Rd., Los Angeles 64, Calif. (A)

CHANGES IN GRADE

Miller, William J., (A) to (M)
Roberts, Paul M., (S) to (A)

SMPTE Lapel Pins

The Society will have available for mailing after September 15, 1952, its gold and blue enamel lapel pin, with a screw back. The pin is a ½-in. reproduction of the Society symbol — the film, sprocket and television tube — which appears on the *Journal* cover.

The price of the pin is $4.00, including Federal Tax; in New York City, add 3% sales tax.

Meetings

72d Semiannual Convention of the SMPTE, Oct. 6-10, Hotel Statler, Washington, D. C.

Other Societies

International Society of Photogrammetry, Conference, Sept. 4–13, Hotel Shoreham, Washington, D.C.

American Standards Association, Third National Standardization Conference, Sept. 8–10, Museum of Science and Industry, Chicago, Ill.

Illuminating Engineering Society, National Technical Conference, Sept. 8–12, Edgewater Beach Hotel, Chicago, Ill.

Biological Photographic Association, Annual Meeting, Sept. 10–12, Hotel New Yorker, New York

National Electronics Conference, Annual Meeting, Sept. 29–Oct. 1, Sherman Hotel, Chicago, Ill.

Optical Society of America, Oct. 9–11, Hotel Statler, Boston, Mass.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 13–17, New Orleans, La.

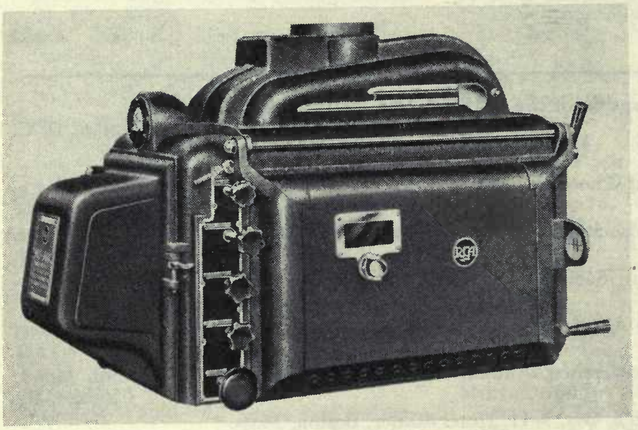
American Standards Association, Annual Meeting, Nov. 19, Waldorf-Astoria, New York

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal.*

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.

This 5000-w Featherlite, weighing only 21 lb, is among the spotlights and other new studio lighting equipment described in a brochure by Century Lighting, Inc., 521 W. 43d St., New York 36, N.Y. Other equipment is: aluminum barn doors, mechanical dimmers, light lifts, hangers and mike boom.



The Hy-Arc is a new carbon-arc projection lamp for indoor and medium-size drive-in theaters that has been announced by the Theatre Equipment Section, RCA Victor Division of Radio Corporation of America, Camden, N.J. Features of the lamp are: a system of magnetic stabilization of the arc flame; water-cooled, nonrotating positive carbon; and a 15-in. high-speed reflector. The lamp's output is approximately 18,000 lm. It operates with a 9-mm × 20-in. high-intensity positive carbon and a $\frac{5}{16}$-in. × 9-in. negative carbon at currents from 70 to 90 amp.

SMPTE Engineering Activities

A report by F. T. BOWDITCH, Engineering Vice-President

THE ENGINEERING ACTIVITIES of the Society of Motion Picture and Television Engineers are much more extensive than perhaps most members realize. Engineering Committee reports appear in the *Journal* from time to time, but usually these give a detailed picture in a rather limited field rather than a broad view of the total activity. The frequent publication of proposed American Standards is another evidence of Society engineering activity, but this has sometimes created the feeling that the preparation of Standards proposals is the only activity in which the Engineering Committees of the Society are engaged. For these reasons, the writer has been encouraged to prepare this present report, designed to provide an overall picture which, while perhaps over-simplified in the particular details most familiar to any one reader, will at the same time give him information of general interest in other less familiar fields.

Editor's Note: This report, scheduled for some time for the *Journal*, now has special significance as a summing up by Engineering Vice-President Bowditch who, because of new responsibilities at the Research Laboratories, National Carbon Company, Cleveland, Ohio has found it necessary to resign before the expiration of his present term. He has served the Society as its Engineering Vice-President since January 1950.

Foremost in the engineering activities of the Society is of course the work of its Engineering Committees. From 1 to 75 pages of any individual *Journal* issue may be devoted to this field, and a check of *Journals* since January, 1950, shows an average of about 17 such pages per issue. This includes not only Committee Reports and the publication of proposed and final American Standards, but records of Convention symposia growing out of Committee deliberations on such widely different and often highly controversial subjects as preferred screen-viewing conditions, proposed magnetic film standards and 16mm emulsion position. A complete bibliography of Engineering Committee publications would thus be very extensive indeed, and much too long for inclusion here. For this reason, the references cited are confined to publications during the writer's term of office—except for a few much earlier ones of historical interest.

The Society prides itself on providing in these Committees a completely neutral atmosphere, without commercial bias, where the most active competitors can get together to work out their common problems. A more complete statement of the high regard in which the Society holds its responsibilities here will be found in the policy statement[1] published by the writer soon after assuming the Engineering

Vice-Presidency in January, 1950. It will be noted from this that while the Engineering Committees do determine appropriate test methods, and sometimes set limits characteristic of good performance, the Society is never permitted to become involved in the application of these to the comparative rating of competitive merchandise.

As has been implied, a major activity of the Engineering Committees is the determination of proposals to be recommended as American Standards. An American Standard can only be validated by the American Standards Association, according to a procedure which will be described later; but a great deal of spadework is required to reconcile competitive viewpoints and to phrase a proposal combining the resultant area of agreement with the technical accuracy necessary to a useful standard. In motion picture and related television fields, the spadework for a particular standard is done by one of the Engineering Committees of the SMPTE. This arrangement is a relatively recent one, and much simpler than before, as will be explained later. Also, since SMPTE as sponsor of ASA Sectional Committee PH22 is responsible for the general organization and work program of this Committee, the Engineering Vice-President is able to cooperate effectively within the ASA toward this same goal of a simplified Committee organization of maximum efficiency.

Particularly with the expansion of the Society's interests into related fields of television, possibilities for conflict developed between the agenda of SMPTE Engineering Committees and those of other technical societies. This soon led to the formation of a steering committee, which now bears the impressive title "Joint Committee for Inter-Society Coordination," and is composed of two delegates each from IRE, RTMA, SMPTE and most recently NARTB. The several committees of SMPTE in television fields have been set up with the knowledge and guidance of this group, and their agenda coordinated with those of potentially conflicting Committees of the other Societies represented. Here too an unnecessary burden was formerly placed upon many industries asked to contribute the time and expenses of technical employees to the Committees of several societies simultaneously engaged in solving what seem to be the same problems. It is the purpose of the JCIC Committee to eliminate such waste, at least among the member Societies. The Chairmanship of this group rotates among the eight members on an annual basis, each Society being represented in turn. Mr. Axel Jensen started things off last year as the IRE representative, while the writer is serving for SMPTE during 1952.

In the following paragraphs the origin and the work of each of the Society's Engineering Committees will be described in turn. From this it will be apparent that much besides American Standards proposals occupies these groups, and it is hoped that some useful measure of the important services rendered to the Society and to industry will be brought out.

Color

This Committee has been continuously active since its creation in 1929, and is thus one of the oldest committees of the Society. Dr. Herman H. Duerr of Ansco has just concluded two very capable terms as chairman, and has now been succeeded in this post by Dr. J. P. Weiss of Du Pont. The sixteen members of the Committee are chosen to represent the film and equipment manufacturers, as well as the studio users of color film. Although no American Standards have been needed recently in this field, the Committee has been actively concerned with such matters as a color process symposium, color sensitometry, color film sound

tracks, spectral requirements of light sources and projection screens and light-source color measuring instruments as applied to photography. A subcommittee under Lloyd Goldsmith prepared a very complete table on "Characteristics of Color Film Sound Tracks,"[2] and another subcommittee under Carl Overhage published an excellent 72-page treatise on "Principles of Color Sensitometry."[3] These two examples illustrate very well the important work in fields other than standardization which is being done by the Engineering Committees of the Society.

Curiously enough, the one proposal for standardization which this Committee has received in recent years was necessarily postponed until the trade situation is further clarified. It was pointed out to the Committee that several sorts of color film are presently on the market, each balanced for photography with an incandescent tungsten light source of a different color temperature. Standardization on a single color temperature would obviously provide for simpler stocking of film and of light sources, and so would seem a proper subject for consideration by the Committee; moreover, if the lower color temperature could be made standard, lamp life would be much prolonged. It was soon agreed, however, that standardization was not appropriate at this time because many economic factors remain to be clarified before the best balance between picture quality, film speed and light color and intensity can be determined. The Society has no right, nor in fact does it have the power, to force a single standard where substantial unanimity cannot be secured; nor are the facilities available to conduct extensive technical studies under Society auspices, and so assume the responsibility for securing the one best answer to a complicated problem such as this one.

C. Francis Jenkins, first president of this Society, gives excellent precedent for this present-day action in an address on "Society History"[4] delivered in 1918. Reporting an unsuccessful attempt "to adopt an alleged ideal specification for a projection machine" on account of the objections "by makers of diverse models," he concluded as follows:

"It did one thing, however, well worth while. It clarified the atmosphere and made more distinct to me and perhaps to others of us, the objects for which this Society was organized and even more strikingly the things for which it is *not* organized.

"For example, the Society of Motion Picture Engineers is not a judicial body to settle controversies between conflicting interests or to promulgate recommendations which make for class-discrimination. If our Society ever degenerates into a contest between factions each trying to use the Society for personal advantage, then our usefulness is ended and our organization will soon break up as others in the motion picture industry have already done.

"What we *did* organize for was to set our official seal on standards generally recognized as standards; and second, and perhaps best of all, to put into permanent form for world-wide distribution, the specialized knowledge which our members, experts in their particular line, are so unselfishly furnishing for this purpose. And while the official stamping of generally acknowledged standards is a necessary duty, for myself I have found the most interest in our meetings has come from the valuable papers read and printed, and I don't believe the limited time of our meetings can be spent in a more worthwhile manner."

Film Dimensions

This is a relatively new Engineering Committee, established in 1948 by the preceding Engineering Vice-President, John A. Maurer. The Society has been active in the field of film dimensions from the very beginning, however, as

witness the presentation by Donald J. Bell of a paper on "Motion Picture Film Perforation" at the meeting of October 2–3 in 1916, the second formal meeting of the Society. Bell's demand for standardization started a continuing activity, through first a "Committee on Cameras and Perforations" in 1916, then a "Committee on Film Perforations" in 1921, which continued as a subcommittee of the Committee on Standards from 1924 to 1948. In line with the philosophy of simplification previously expressed, the long-standing importance of film dimensions was once more recognized, and the former subcommittee was made a full-fledged Engineering Committee in 1948. Dr. Emmett Carver of Eastman Kodak has been the very competent Chairman of this group since its formation, the members representing the film manufacturing companies and those most concerned with the handling of film through apparatus in which dimensional tolerances are critical.

The biggest problems facing this Committee at present are those relating to the introduction of the new safety-type film bases. Film is ordinarily slit to dimension and perforated at the time of manufacture. After an indeterminate period of time, involving perhaps prolonged storage under various humidities and temperatures, and chemical processing, this film must pass smoothly and with great accuracy of positioning through a camera, printer, projector or perhaps some other sort of specialized film-handling equipment. The critical dimensions of these equipments have been chosen by long experience to match the characteristics of the old-style film base. Now, with new bases with different dimensional changes being introduced, the shoe is on the other foot: the film manufacturer must alter his initial slitting and perforating dimensions so that the dimensions in critical usage will be the same as before. American Standards for film dimensions presently "apply to the material immediately after cutting and perforating": the later dimensions at the time of film passage through an apparatus of some sort are of course known to be most important, but to date no one has been able to visualize a suitable procedure for extrapolating these back to the time at which the slitting and perforating is done.

Another problem of this Committee has been concerned with the possible choice of a single preferred shape for the sprocket perforation of 35mm positive and negative film. A proposal for this[5] has been forwarded to the Committee on Standards with the recommendation that it be made an American Standard.

Finally, a recent policy decision in the field of film dimensioning is worthy of notice. Not all film is slit at the time of manufacture. 16mm and 8mm film stock is sometimes provided double-width, to facilitate processing, with final slitting-to-width done after processing. For one reason or another, a good deal of the film made in this way has not been slit with the accuracy in width required to meet the American Standard dimensional tolerances, and poor sound reproduction, excessive picture weave and even film jamming in projection has resulted. The Committee considered the desirability of preparing a second and less rigid dimensional standard for 16mm film, to apply only to film slit from 35mm or 32mm stock after processing. This idea was soon rejected, however, on the basis that the present 16mm dimensional specification is required for interchangeable performance in all equipments, without reference to the manner in which the film is made. Thus there is no logical reason to let down the bars solely for the purpose of permitting all laboratory-slit product to qualify under a Standard of some sort. Since American Standards are not compulsory, a considerable market can and often is developed in nonstandard merchandise of all sorts.

It was concluded, however, that the demonstration of the existence of such a market is no reason to dignify it with a high-quality label.

Film Projection Practice

No matter what talent and expense have gone into the preparation of a fine motion picture film, the film must finally be projected with proper skill and good equipment in order to yield the proper end product. Projectionists and equipment manufacturers alike have always recognized this critical importance of high-quality projection, ever since this Committee was first established under the chairmanship of F. E. Richardson in 1928. Many will recall the fervent pleas for good projection practice which were a valued contribution of Mr. Richardson to the Convention sessions of more than a quarter century ago. He was perhaps more responsible than any other person for halting the early practice of referring to the men in the booth as simply "operators," and seeing to it that the more appropriate term "projectionist" came into common usage.[6] The torch is presently being carried by Ralph Heacock of RCA, who has recently succeeded M. D. O'Brien of Loew's in this important Chairmanship. A few years ago the word "Film" was added to the name of this Committee, in recognition of the advent of television projection in theaters, and the assignment of this latter aspect to the Committee on Theater Television.

The membership of the Committee on Film Projection Practice is presently composed largely of projection equipment manufacturers and theater circuit representatives, although we would like to add more projectionists to this group. An interesting agenda includes revision of the projection room plans, the possible preparation of projection room maintenance instructions, preparation of a proposed standard for arc-lamp mounting dimensions and the review of three American Standards dealing with projector aperture dimensions, basic projection room and lens dimensions and 35mm projection reels.

Films for Television

This Committee was first formed early in 1950, in line with the expanding interests of the Society in television fields. Previous to 1950, only two SMPTE television committees were in existence — one on Theater Television and one on simply Television. The latter became unwieldy as interests broadened, and so was divided into three Committees, on Films for Television, Television Film Equipment and Television Studio Lighting, respectively.

The Committee on Films for Television is chaired by Dr. R. L. Garman of General Precision Laboratory, and is staffed by film, equipment and television studio representatives. The committee is concerned with the special problems of film as used in television, and has been especially active in the field of "Television Test Films"[7] which has presented some very difficult problems, and in the preparation of a "New All-Purpose Film Leader"[8] by a very capable and energetic subcommittee led by C. L. Townsend of NBC. Other projects include a study of the problems concerned with pictorial quality of films for television use, and a study along with other Committees of the long-standing problem of 16mm emulsion position.[9] The reference noted should be consulted by those interested in this problem. The television picture and sound problems arising from the indiscriminate use of film for projection with emulsion sometimes facing the light source and sometimes the lens, was thoroughly discussed during the October 1951 Convention in Hollywood.[10] It was agreed then that it is up to the purchaser to specify and pay for the emulsion position he wants, and some television studios

report very good success in this way. The Hollywood symposium on 16mm emulsion position is worthy of special mention here as a typical example of an engineering service growing out of Engineering Committee activity.

High-Speed Photography

This Committee was first organized by Engineering Vice-President John A. Maurer in 1948, with John H. Waddell as Chairman and with a membership representing film and equipment manufacturers along with an excellent representation of the users of this very specialized equipment. Under Waddell, this group got off to a most energetic start, although more along the lines of a Papers Committee in its field, rather than with an agenda of engineering problems to be solved as is the case with the other Engineering Committees. In the papers field, the Committee on High-Speed Photography has sponsored technical sessions for one or more days at several Conventions and has published "A Survey of High-Speed Motion Picture Photography" and a "Bibliography on High-Speed Photography,"[11] while sponsoring the "High-Speed Photography Question Box."[12] A "Subcommittee on Technical and Engineering Society Liaison" was organized last year with representatives from about twelve other technical organizations, although it is too early to judge what may come from this attempt to correlate all technical-society effort in this field.

When John Waddell's permissible limit of two terms (four years) as Chairman terminated last January, we were fortunate in securing the services of Dr. Harold E. Edgerton of M.I.T. in this post. With the planning of an International Symposium on High-Speed Photography for the Washington meeting next October, the Committee is continuing its typically fast pace along this line.

Laboratory Practice

This is another of the Society's long-standing Committees, organized first as a committee on Laboratories in 1921, then Development and Care of Films in 1931, Laboratory and Exchange Practice in 1933, and finally as a separate Committee on Laboratory Practice since 1935. This Committee has never operated with more energy and effectiveness than during the last few years under the Chairmanship of John Stott of Du-Art Film Laboratories. Membership is recruited largely from the processing laboratories, as the title would suggest.

Projects of this group include the determination of a standard screen brightness for 16mm review rooms, so that the customer and the laboratory may judge the product on an agreed common basis. Difficulties presently arise here on account of the conflicting demands of the Armed Services for thin prints to be projected at low light levels, and the need for dense prints for the amateur's small, beaded screens and 1000-watt projection lamps.

The standardization of printer cueing devices is another project of much potential value. Negatives circulate widely between laboratories and since there is no present agreement respecting these cueing devices, much patching and mutilation of the film results.

Emulsion position with 16mm positive films has also been discussed long and often by this group. Here too it is concluded that no single standard will ever be observed until the customers apply the necessary pressure and agree to pay the extra cost where this is involved. Standard magnification ratios when printing between 35mm and 16mm film sizes, and assistance to the Armed Services in setting up better specifications for print quality are other problems. The recent establishment of a Chemical Corner[13] in the *Journal* is

another important service provided by this Committee.

Motion Picture Studio Lighting and Process Photography

A Society committee on Studios was first organized in 1917, followed by one on Studio Lighting in 1928, which has operated continuously since that time. The term "Motion Picture" was added to the Committee title in 1950 to distinguish this from the newly created Television Studio Lighting Committee. A former Committee on Process Photography was combined with the Studio Lighting Committee in 1951, following a six-year period of carrying the former on the books as "under organization," with little evidence that such organization was really needed.

This illustrates another basic principle of Engineering Committee operation. These Committees come and go — and perhaps return again — as the needs of the industry require. There is never any intention to carry a Committee simply as a listing of names in the *Journal*, and such a listing is terminated as soon as reasonable efforts to stimulate activity prove unsuccessful. Activity solely for activity's sake is never encouraged; but if there is useful work to be done, every effort is made to enlist competent persons to do it.

M. A. Hankins of Mole-Richardson has recently concluded a very competent two-term maximum as Chairman of the Committee on Motion Picture Studio Lighting and Process Photography, and he is now succeeded in this post by John W. Boyle, Director of Photography. This group is based in Hollywood, and is composed of studio lighting equipment representatives and persons who are concerned with set lighting. Since the proper use of lighting is largely a matter of art, the field of the engineer is limited here. In spite of this, the Committee regularly prepares comprehensive reports[14] which are most useful in acquainting the industry with the latest things in set illumination equipment and their studio usage.

Another motion picture studio group, the Committee on Cinematography, also based in Hollywood, was temporarily inactivated a year ago, after no interest had been manifest for a considerable number of years.

Limited West Coast activity in Society Engineering Committee work is no doubt in part the result of basing the Engineering direction almost 3000 miles away, in the New York headquarters of the Society. Another factor, of course, is the fine work of the Motion Picture Research Council and of the American Society of Cinematographers in related fields. The Society enjoys the best possible cooperation with these organizations, and of course has no interest in attempting to duplicate their work. Nevertheless, the Engineering Vice-President has repeatedly felt a sense of responsibility to encourage more activity in the West Coast committees which are part of the traditional engineering organization of the Society. Any suggestions here will be most welcome.

Optics

Reference to the first volume of the *Transactions* of our Society indicates a very early interest in the subject of optics, a Committee on Optics having been formed in October 1916 and remaining active through 1923. From 1930 through 1934 a Committee on Projection Theory was concerned with this field, but this was absorbed by the Committee on Standards in 1935. Finally, a subcommittee of the Committee on Standards was once again given full committee status in 1950 with the establishment of the present Committee on Optics. Dr. R. Kingslake of Eastman Kodak has served as Chairman since that date.

The first major assignment of this Committee has been the preparation of a proposed standard for the photometric calibration of camera lenses. The group

has agreed on two methods, either of which gives accurate results. A recommendation has also been submitted respecting the standardization of an associated lens marking system in so-called "T-stops," but this portion of the proposal is finding considerable opposition from those who feel that the validation of a T-stop lens marking method will lead amateurs to expect a greater exposure accuracy than will likely result. The Committee has done a very excellent technical job in specifying accurate calibration methods, a procedure which has been much facilitated by the generosity of the Radio Corporation of America in granting licenses under a patent issued to L. T. Sachtleben of RCA. If the T-stop versus *f*-stop controversy proves insoluble, it is hoped that the test methods can in some way be made standard, independent of the provocative term "T-stop."

Other projects of this group include the specification of lens mounting dimensions for 35mm, 16mm and 8mm film projectors, and standard lens resolution test procedures.

Screen Brightness

The present Screen Brightness Committee dates back to the Committee on Theater Engineering of 1941. This latter Committee consisted at that time of a combination of several subcommittees, including one on Screen Brightness. This subordinate status continued through 1945, after which the several subcommittees of the Theater Engineering Committee were each given full Engineering Committee status. Dr. W. W. Lozier of The National Carbon Company is the present Chairman of this very active group.

A major activity here has been the screen brightness survey,[15] which has now been extended to cover 125 indoor theaters and 18 West Coast 35mm review rooms. Much helpful information has been secured, and this is being extended to include a representative number of drive-in theaters. An important aspect of this work has been the specification of a suitable light-measuring equipment and method of use.

A symposium on screen viewing factors[16] was sponsored by this Committee, providing not only a most instructive Convention session but also more than 50 pages of technical papers in the *Journal*. The great importance of these screen viewing factors is fully recognized by the Committee, which is presently working to stimulate commercial interest in the psychological test procedures required to get the audience reaction data needed.

A basic problem in standardization recently developed when a question arose respecting the omission of drive-in theaters from the American Standard specification of screen brightness (10^{+4}_{-1} ft-L). No commercial projection equipment can presently supply, nor will present film withstand, the quantity of light required to illuminate large drive-in screens to this level. So, no matter how good his intentions, the owner of a drive-in can only meet the present American Standard by cutting the size of the screen and the capacity for customers to an impractical extent. Rather than give a "nonstandard" label to all the drive-in theaters in the country, the Committee therefore voted to omit them altogether from the specification. This is in line with the basic principle that an American Standard should be a commonly accepted practice, capable of realization in a commercial way, and not simply a theoretical quality goal for the indefinite future.

The Screen Brightness Committee now has active Subcommittees on: Meters and Methods of Measurement, Projection Screens, and Illumination Practices.

16mm and 8mm Motion Pictures

This group was first organized as the Committee on Nontheatrical Equipment in 1931, assuming its present title in

1946, in recognition of the growth of 16mm usage to include important theatrical as well as many other significant high-quality applications. Because there is much less film area than with 35mm film on which to record picture and sound information, the 16mm engineers are encouraged to seek the best possible quality in all their operations. Learning in this way what careful attention to quality can produce, these engineers have made of this Committee a very active forum for the exchange of ideas and information, and an effective influence for higher quality in all phases of the industry.

This interest in all phases calls attention to the fact that this Committee is the only one set up along product rather than along process lines, so that opportunities for conflict with the work of the other committees frequently arise. For instance, problems in 16mm film dimensions, laboratory practice, sound, etc., might equally well be handled by the committees in these particular fields. This situation has developed from the early days when 16mm was regarded as "substandard," and no one even thought of 8mm film. 35mm sound engineers, as an example, had no interest in 16mm, so that two entirely different groups of people were required to represent those interested in the 35mm and 16mm applications respectively. Now that this is no longer true, tradition and a very active record of accomplishment have operated to maintain a committee which would probably not be reorganized at all if we were to ruthlessly start over again in the light of the present-day committee arrangement. However, no Society would be foolish enough to disband or even to limit the work of a group as active and as useful as this one continues to be.

This Committee in recent years has done an outstanding job of developing American Standards proposals, a total of approximately 20 being presently in various stages of negotiation through final confirmation. Much of this has come from intensive work with the Armed Services during World War II, directed toward the determination of a JAN (Joint Army-Navy) specification for a 16mm projector.

In addition to being the most active Committee in the development of standards proposals, the 16mm and 8mm group is working on recommendations for 16mm review rooms, especially sound reproducing equipment, a test film for checking the resolution of projector optical systems, and the preparation of a booklet on 16mm and 8mm Projection Practice.

The Committee has been faced with many difficult standardization problems, in some of which unanimous trade agreement has been impossible to achieve. The familiar one of 16mm emulsion position is an outstanding example; although an American Standard does exist here, this is frequently ignored and serves mainly to demonstrate the futility of a Standard which does not have the acceptance of all concerned. Another classic case is the specification of the guided edge in several standards dealing with 16mm film. Projector manufacturers were not in agreement in their choice of the sound-track versus the perforated edge, since good design reasons existed for either one. Now, however, a reversal of the earlier majority opinion is in prospect, on account of the prevalence of increasing amounts of substandard 16mm film, inaccurately slit from 32mm or 35mm after processing, and so providing a very inaccurate reference edge for the positioning of the picture and sound-track areas.

Present-day difficulties in arriving at a standard here are reminiscent of Mr. Jenkin's experiences with the first standardization efforts of the Society, which were previously quoted. Standards defining a preferred design for quality reasons create many debatable issues, and these should ordinarily be left for independent resolution by each

designer, where critical interchangeabilities are not involved. Let the Society specify standard test methods, including test films, so that the customer may determine matters of relative product quality in a reliable manner; but let us avoid labeling any particular product as substandard except where critical interchangeability is involved, or complete unanimity achieved.

A final example of this kind is the effort made in 1948 to revise an earlier American Standard for 16mm sprocket design, including features intended to insure better quality rather than simply interchangeability. Sprockets of a design different from that of the proposed standard were stated by a major manufacturer to be in wide successful use, and his engineers did not agree that the design proposed as standard was any better than this. Further, to quote E. W. Kellogg[17] ". . . if a manufacturer puts out a machine which performs well with a standard film, and the film is not subjected to undue wear, and his customers are happy . . . it is no one else's business what shape tooth he uses." Thus the difficulties first experienced by Mr. Jenkins returned to trouble us once more. In the sprocket case, the Committee on Standards adopted a form of recommendation, which would permit competent technical material of this sort to be published in an authoritative manner for the general education of the industry, while at the same time avoiding the application of a nonstandard label to all other designs. This form of publication[18] is reserved for standards proposals which fail to secure the unanimity necessary for standardization, but which do embody much good technical material, thought to be of general trade interest.

Henry Hood of Eastman Kodak has just concluded a very capable 4-year term as Chairman of the 16mm and 8mm Motion Pictures Committee and has now been succeeded by Malcolm Townsley of Bell & Howell. The large membership of 23 persons reflects the wide range of interests represented.

Sound

When talking motion pictures arrived with startling suddenness in the late 1920's, they brought many technical problems, and with them, the creation in 1930 of the SMPE Committee on Sound. This is presently the largest of all the Engineering Committees, including 27 persons with the Chairman (West Coast) and Vice-Chairman (East Coast). Representatives of the 35mm studios, the 16mm and 8mm industries, and television combine with the sound equipment, film and magnetic tape suppliers to give a very complete coverage of the field. Lloyd T. Goldsmith of Warner Bros. has just completed four very competent years as Chairman, and he has now been succeeded by John Hilliard of Altec-Lansing — also of Hollywood. Glenn Dimmick of RCA continues as Vice-Chairman in the East, and in his Chairmanship of the very important Magnetic Subcommittee.

Major problems in this group have to do with standardization, particularly respecting magnetic sound. A very important symposium respecting magnetic film standards was sponsored during the Hollywood convention last October[19] giving opportunity for a very frank and open presentation of the opposing viewpoints. Here is a case where the need for a single standard was recognized by all concerned, although each conflicting system had been chosen by its sponsor for reasons thought to be valid. The invaluable opportunity offered by the Society as an impartial meeting ground for active competitors is well illustrated here, and there is every reason to anticipate the early determination of the single standard needed.

In addition to active work on many standards, the Sound Committee does

a great deal of work on test films, being presently concerned with the specification of new ones related to magnetic sound.

Standards Committee

This is the most venerable and honorable of all the Engineering Committees, going back to the very early days of the Society. Standardization in the first years was "Adopted in Committee of the Whole Society," as witness the first "Motion Picture Standards" published in the first volume (1916–1920) of Society *Transactions*.[20] These apparently resulted from the recommendations of one of the four engineering committees of that time, in fields of Cameras and Perforations, Motion Picture Electrical Devices, Projection Machines, and Optics, respectively. In 1924, a Committee on Nomenclature and Standards was formed, this being changed to the present title in 1934.

For many years, standardization proposals were developed by subcommittees of the Standards Committee, by subcommittees of ASA Sectional Committee PH22 on Motion Pictures and by any one of the several Engineering Committees of SMPTE. This finally led to the realization that the most competent people in particular fields have already been brought together in the respective Engineering Committees of SMPTE, so that it is most efficient to refer all Standards work projects directly to these Committees, rather than to appoint members of these same Committees as a subcommittee of the Standards Committee or of ASA Sectional Committee PH22.[21] This procedure was first inaugurated by John A. Maurer and was further facilitated by his appointment of all Engineering Committee Chairmen as members of the Standards Committee. The balance of the Committee serves ex officio, and includes a representative of the Motion Picture Research Council, the chairman of ASA Sectional Committee PH22, the Past Engineering Vice-President of SMPTE and the Past Chairman of the Standards Committee. This insures a most competent and experienced group of engineers, well qualified to handle the policy-type matters which come before it, along with the processing of standards proposals. While the basic policies which are cited as examples throughout this report are the responsibility of the Engineering Vice-President, these are in general the result of discussions with the Standards Committee, and the determination of a consensus there.

The dean of the motion picture standards business is generally recognized to be Dr. Emmett Carver of Eastman Kodak, who served as Chairman of this Committee for many years. Dr. Carver brings a very fine attitude of patience, impartiality and technical thoroughness to these deliberations, and his capabilities are universally respected by those who work with him in this field. Frank E. Carlson of General Electric has just completed a competent four-year term as Chairman of the Standards Committee, and has now been succeeded by Henry Hood of Eastman Kodak. Hood's recent appointment to fill the remainder of the current Engineering Vice-President term creates a vacancy here which has not been filled at this writing.

Stereoscopic Motion Pictures

The April 1952 *Journal* was the first to list this new Committee, formed since the first of this year. Started a few months ago as a task force to report on the extent of trade interest in the formation of such a permanent Committee, the group found the response was immediate and very enthusiastic. John A. Norling is the ambitious Chairman of this new Committee, and while it is too early to predict the relative importance and permanence of this group, present indications are certainly favorable. Two projects presently under way are concerned with stereoscopic

nomenclature and with the preparation of a bibliography of this field.

Joint RTMA-SMPTE Committee on Television Film Equipment

This Committee is an outgrowth of negotiations in the Joint Committee on Inter-Society Coordination. As previously noted, the SMPTE realized late in 1949 that television interests in the Society had grown too large to be contained within the Committees on Television and on Theater Television. The latter was specific enough, but the handling of all other interests in a single Committee on Television was no longer practical. A few months prior to any definite action by SMPTE, the RTMA independently realized the need for technical committee activity in the field of television film-handling equipment, and so formed a very capable Subcommittee of Subcommittee 4 of RTMA Committee TR4, bearing the designation TR4.4.2. Thus, while SMPTE was making up its mind, the independently conceived RTMA Sub-Subcommittee came into being, squarely in one of the fields contemplated by SMPTE, and immediately gave evidence of energetic competence. The individual members of the RTMA committee might just as appropriately have been serving with SMPTE, since the same commercial organizations and most often the identical persons are the ones most logically chosen whenever a competent Engineering Committee is formed in a specific field such as this one. As an example, seven of the twelve-man TR4.4.2 Committee were already SMPTE members, including the Chairman. Thus it was quite impractical for SMPTE to attempt the formation of an altogether different Committee to do this same job, even though this was obviously in a technical field where the Society was most expert. Hence the formation of the coordinating Committee, and the agreement with RTMA that this would henceforth become a joint committee of the two Societies. Details remain to be worked out, since the formal procedures respecting membership appointment and chairman selection are not the same in the two sponsor organizations. Here too the JCIC will prove helpful.

Dr. Frank N. Gillette of General Precision Laboratories continues as Chairman of the Joint Committee, with Dr. E. C. Fritts as Vice-Chairman, representing SMPTE. To the original membership of 12, appointed by RTMA, SMPTE added six more, from film and film equipment agencies not previously represented. A major project of this group is the preparation of a 16mm projector specification, incorporating the special requirements of television usage. Other projects include a standards proposal for dimensions of slides and opaques, and one for picture dimensions on 16mm and 35mm motion picture film.

It should be mentioned here that among the new Committees originally considered by SMPTE in the field of television was one on Video Recording, listed as "under organization" in the April, 1950, listing of Committees of the Society. In discussions of this in the JCIC, it was agreed that aspects of this operation of interest to SMPTE would properly come before the Committees on Film for Television and Television Film Equipment. The SMPTE Committee on Video Recording was thus allowed to disband before the organization phase was completed. An IRE Subcommittee on Video Systems and Components is in potential conflict here, but it has been suggested through the JCIC that this latter group do no work on film handling equipment.

Television Studio Lighting

This is another of the new television committees resulting from the expansion of the old Committee on Television. Since this field is not in potential conflict with the technical committee work

of the IRE, RTMA and NARTB, this has been agreed to be outside the field of interest of the JCIC.

The Society has, however, been engaged in a running argument with The Illuminating Engineering Society respecting duplication of effort here, which was resolved for a while by an IES agreement to leave this to SMPTE, while working in IES with the lighting problems associated with television viewing. This agreement has since been abandoned, however, so that two separate technical committees of quite similar membership presently exist in the field of television studio lighting, one sponsored by SMPTE and one by IES. We have recently explored the possibility of reducing this to a single Joint Committee of the two Societies, as with Television Film Equipment, but this has so far been unsuccessful, and further efforts have now been abandoned.

It has been accepted as a basic policy of the SMPTE Committee that only those projects shall be undertaken which are of admitted interest to the television studio engineers. Equipment makers and other suppliers of the studios are in the minority on the Committee, and serve primarily as sources of information.

Richard Blount of General Electric is serving his second term as Chairman of this Committee, and is presently active in promoting the chosen Committee objectives of: (1) defining means for the measurement of television studio lighting, both incident and reflected; (2) terminology; and (3) the possible standardization of electrical plugs.

Test Film Quality

This Committee was first organized in 1944, in order to provide expert advice respecting the maintenance of proper quality of the Society's test films.

Responsibility for defining the content of one of these test films lies ordinarily with the Engineering Committee most concerned, as does the suggestion of new test films as their need becomes apparent. The Quality Committee, on the other hand, sees to it that appropriate controls are devised and maintained to insure that the films made are in accordance with these specifications. With the full time employment of Fred Whitney about one year ago, Society headquarters facilities for test film quality maintenance have been much augmented.

The present Chairman of this important Committee is Fred Pfeiff of Altec Service Corp., who is exceptionally well acquainted with test film quality considerations from the user's standpoint. The Committee membership consists of persons expert in the processing of high quality film, including a representative of the Motion Picture Research Council.

Theater Television

This Committee was first organized in 1944 as a Subcommittee on Television Projection Practice of the Committee on Theater Engineering, acquiring the present title of "Theater Television" in 1948. The group has operated to date largely as a policy Committee, and for the purpose of assembling and distributing technical information of interest in this important new field. The Society has also appeared before the Federal Communications Commission, presenting data secured through this Committee relating to the nature of the facilities thought necessary for a theater television distribution system.[22]

Largely as the result of the stimulation provided through this Committee, many business groups became actively interested in theater television, and these have also appeared with increasing enthusiasm before the FCC in support of this new medium. Finally, it became apparent that the services of the Society were no longer needed to plead this cause, and the Theater Television Committee recommended that the Society

make no further appearances before the FCC since "the new industry is well able to solve its own *commercial problems*." The statement "Theater Television and the FCC,"[23] should be consulted for further details.

It is anticipated that this Committee will some day be concerned predominately with the engineering problems arising from the operation of television projection equipment in theaters. Consideration is also being given to undertaking a study of color television systems as applied to theater use. For the moment, things must stand by until the oft-postponed FCC hearings are out of the way, since these must occupy the first interest of many of the Committee members. Results of these hearings will also have an important effect on the future field of interest of the group.

Paul J. Larsen was the chairman of this Committee during the very important formative years from 1945 to 1948, and his missionary enthusiasm did much to keep the spark alive when commercial interest waned. Donald E. Hyndman took over in 1948 and brought Larsen's early work up to the point where trade enthusiasm became so great that no further Society participation before FCC was needed.

George L. Beers of RCA is the present Chairman, and in talking his assignment over with the Engineering Vice-President and with Mr. Hyndman (who was forced to resign on account of the pressure of other affairs) the following general field of operation was agreed upon:

"In general the Theater Television Committee should concern itself with the study of the *engineering* factors involved in the production of theater television programs. Rather than attempt to prescribe the minimum picture quality which a theater television screen image must provide in order to be a sales-worthy product, the Committee should indicate the engineering requirements of systems of different quality. In this way the theater industry can have the technical information needed on which to base its own course of competitive action.

"It was pointed out, however, that in spite of our intent to operate primarily as an engineering group, the crystal-gazing aspect might, nevertheless, be requested of us by the FCC. In such an event, an opinion would of course be determined, but in such a way as to distinguish it clearly from the factual engineering data which are to be the main concern of the Committee."

Theater Engineering

Society committee work in this field has been carried on from the very beginning, starting as a Theater Equipment Committee in 1916. From 1940 to 1945 the Theater Engineering Committee provided general directional responsibility for several major Subcommittees which later became full fledged Engineering Committees, i.e., Projection Practice, Screen Brightness, Television Projection Practice, etc. The Committee on Theater Engineering Construction and Operation was one of these to become separately established in 1946, with this long title shortened to the present one of simply Theater Engineering in 1949.

Leonard Satz of Raytone Screen Corp. served capably as Chairman of this Committee, starting in 1948; the present chairman is J. W. Servies of National Theater Supply. Projects studied by this group include theater carpets,[24] air-conditioning, size and mounting characteristics of theater screens, and theater codes. A correlation of the latter as among the several states and cities would be of very great service to industry, and might promote worthwhile standardization.

Thus is concluded the description of the 18 Engineering Committees presently operating for the SMPTE.

Further along engineering lines, the Society is a member of the Inter-Society Color Council and is represented there by a delegation of which Ralph M. Evans of Eastman Kodak is Chairman. Society representation is similarly provided on the U.S. National Committee of the International Commission on Illumination, with Ralph Farnum of General Electric as Chairman. The most extensive of these extra-society engineering activities, however, is that with The American Standards Association, this being discussed in the following paragraphs.

American Standards Association

This is an association of standardizing bodies in many fields of industry, sponsored by industry, and issuing so-called American Standards. These Standards do not of themselves have any force in law, but are generally recognized as representing best practice, and so are frequently incorporated in purchase specifications by agreement between individual buyers and sellers. Elaborate safeguards are provided in the preparation of these standards, insuring the very careful review of all standards proposals by a sequence of authorities terminating in a Standards Council. Provision is also made for the periodic review of all existing American Standards so that obsolete material does not remain on the books.

Standards in the field of motion pictures and in those aspects of television assigned the Engineering Committees of SMPTE are processed through ASA Sectional Committee PH22 on Motion Pictures, presently under the chairmanship of Dr. D. R. White of Du Pont. This ASA Committee is authorized to consider proposals received from any reputable source, but, in practice, almost all of these originate in SMPTE or in the Motion Picture Research Council. In line with the simplification previously discussed, Committee PH22 seldom conducts a technical study in the entire Committee, since the representation is necessarily so broad that adequate technical coverage of any one specialized field is not possible. Subcommittees used to be created to enlist such talent as needed, but this is now handled through the Engineering Committees of SMPTE. Thus with respect to the processing of American Standards, Committee PH22 is largely a policy group, concerning itself more with the need for a particular standard and whether or not an adequate consensus has been reached, rather than with the technical content.

With the recently increased interest in world standards through Technical Committee 36 on Cinematography of the International Organization for Standardization (ISO/TC36), PH22 has now assumed an important new responsibility. The Secretariat of this International Committee is held by the ASA, and the responsibility for expressing the U.S. viewpoint, both respecting world standards proposals and in replying to the proposals of other nations, naturally channels through PH22. Policy matters are decided there, and technical studies requested of the SMPTE Committees where needed. The first international meeting of ISO/TC36 was held in New York City on June 9, 10 and 11, 1952, with PH22 playing an important part in heading the U.S. delegation. U.S. proposals for consideration as International Standards were first recommended by the Engineering Committees of SMPTE, and the Chairmen of the committees concerned with these recommendations were included in the U.S. delegation headed by Dr. White. The Engineering Vice-President of SMPTE was chosen as chairman of this first formal meeting of ISO/TC36, and is most appreciative of having been given this opportunity to work with this very sincere and highly cooperative group. Delegates from Belgium, France, Germany and the United Kingdom worked with the U.S.

group here to achieve substantial unanimity respecting a much greater number of so-called Draft Proposals than anyone had thought possible.

Committee PH22 derives its authority from two sources. First, the Committee is "sponsored" by the SMPTE. This is a conventional arrangement, typical of many other ASA Sectional Committees. The sponsor is responsible for the agenda, and submits his recommendation to ASA respecting the chairman. He is ordinarily required to supply secretarial service, which is very capably done for PH22 by the very versatile Henry Kogel, SMPTE Staff Engineer. Kogel is unusually well fitted for this task, since he also serves as secretary for all the Engineering Committees of SMPTE, previously described.

Within the ASA structure, Committee PH22 is one of five Sectional Committees under the general jurisdiction of a Photographic Standards Board (PSB), of which Paul Arnold of Ansco is the Chairman. The other Committees in this group are:

PH1, Photographic Films, Plates and Papers;
PH2, Photographic Sensitometry;
PH3, Photographic Apparatus; and
PH4, Photographic Processing.

These four represent divisions of the earlier ASA Sectional Committee Z38 on Photography, which became too cumbersome in its operations to continue as a single group. When this reorganization of Z38 into four separate Committees was under consideration by the ASA, the creation of a new correlating Board was also proposed, to which these new PH committees would report in a manner conventional in the ASA with other groups. The SMPTE was asked to agree to a revision of the then independent status of ASA Sectional Committee Z22 on Motion Pictures, so that it too would report to the new correlating Board. This was agreed to, and the designation accordingly changed from Z22 to PH22. Objections were raised at the time to inserting another in the long chain of reviewing agencies between the technical working body on the one end and the Standards Council on the other. However, SMPTE received assurance from the ASA that this was purely an organizational detail within ASA, and that the new Correlating Committee would exercise no significant authority over the affairs of PH22. Correlation is naturally required at some stage to prevent possible duplication of effort between PH22 and the four other PH Committees, and this the new Photographic Standards correlating Board does with very good effect all around. Thus while the rules of procedure of the ASA give correlating Boards in general the right to exercise a considerable degree of authority, this is frequently not used, and it is anticipated that the existence of the PSB will have little effect on the operations of PH22, so long as the SMPTE does a competent job as sponsor.

This then is the present picture of the activities in which the Engineering Vice-President represents the interests of the SMPTE. It is a continual pleasure to work with such a fine, cooperative group of technical people, and particularly with the very refreshing international experience with ISO/TC36 so clearly in mind, it seems altogether tragic and unnecessary that similar progress is not made along political lines. The scientists, however, are showing an ever increasing concern in the study of human reactions, for example in their interest in many phases of the science of color, and the determination of preferred motion picture viewing conditions — so they may yet bring their talents and impartial scientific viewpoints to bear on the troublesome social problems of the world. Having seen the fine cooperative give-and-take in our many Committees, with

axe-grinding at a negligible minimum, one is at least led to hope.

Finally, I wish to express my great indebtedness to the several Chairmen mentioned previously, and to the almost 300 Committee members, whose unselfish cooperation has made this work possible; also, to Society headquarters where Boyce Nemec maintains a most efficient organization and Henry Kogel strives manfully and with very good effect to keep on top of his even score (or is it more?) of secretarial responsibilities. The contribution of my own employer, The National Carbon Company, in granting me the time and expense monies necessary to the conduct of this very pleasant work, is also gratefully acknowledged.

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Explosive Argon Flashlamp

By C. H. WINNING and H. E. EDGERTON

Oscillographic measurements of the light output from argon explosive flashlamps show that the flash duration is about 1 μsec for a 0.5-cm thickness of argon over the end of a cone of cast pentolite 2 in. in diameter. The peak light output is about 200 million cp, and the total output about 200 cp secs. Photographs of the argon lamps were made with a magnetooptic shutter having an effective exposure of about 1 μsec to show the space origin of the light.

THE PHOTOGRAPHY of detonations by means of an ordinary single-exposure camera has been difficult to accomplish for two reasons. First, either the light from the detonation of high-temperature explosives is so actinic as to fog the film; or the light from the detonation of relatively low-temperature explosives such as those of the permissible, coal-mining type, for example, is insufficient to affect the film in the brief exposure time required to stop the motion. Second, although conventional short-flash electronic flashlamps might be considered for some purposes, their use is expensive because the lamp is destroyed by the explosion.

The second difficulty may be overcome, for problems where the subject is not excessively large, by the use of another explosive to produce light at the proper time. A relatively inexpensive, expendable, flash-producing, explosive-activated lamp is described here. The objects of this paper are, first, to present oscillographic measurements of the light output from an argon-filled explosive flashlamp and, second, to present sequence photographs of the exploding lamp itself for correlation with the oscillograms.

Successful photography of self-luminous subjects may be accomplished by the use of Kerr cells, Faraday-effect shutters, and by image-converter tubes. The series of photographs published here of the explosive argon flashlamp during explosion were taken with the Rapatronic shutter (Faraday magnetooptic type).

Argon Flashlamp

In 1937 Michel-Lévy and Muraour published a series of pictures which illustrated that rapidly occurring events, such as the deformation of a lead block by an explosive, could be photographed at desired instants during the process through proper use of the short, intense

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Presented on April 23, 1952, at the Society's Convention, at Chicago, Ill., by C. H. Winning, E. I. duPont de Nemours & Company, Explosives Dept., Eastern Laboratory, Gibbstown, N.J., and H. E. Edgerton, Massachusetts Institute of Technology, Electrical Dept., Cambridge 39, Mass.

luminosity of the shock wave generated in argon gas by a small amount of a brisant explosive.[1]

Shock-wave flashes of about 4- to 20-μsec (4 to 20 $\times$ 10^{-6} sec) duration and 300–600 million cp intensity were produced by detonating 0.4–5.0 cm^3 of a brisant explosive (tetranitromethane plus toluene) in the end of a small, grooved brass cylinder, above which was a cellophane tube filled with the argon. The cellophane tube and the brass cylinder had the same diameters, namely 8 mm or more. The vertical cellophane cylinder of argon traversed by the luminous shock wave had a height of about 8 cm.[2,3] Apparently the selected materials and dimensions favored the production of brief, intense luminosity.

Later investigators who employed the argon flashlamp in photographing various explosive phenomena used modified forms of the lamp. Shepherd reported use of a lamp consisting of approximately $\frac{1}{4}$ oz of pressed tetryl inside a cardboard cylinder 2 in. in diameter. The end of the cylinder had a cellophane window.[4] The duration of luminosity of the flashlamp was estimated to be 2–4 μsec. The pictures, which were taken by either front or back lighting (silhouette), illustrated that the light from the argon flashlamp, even though spread over the expanse of the subject at different selected stages in the explosion process, was much more brilliant than the hot gas from the permissible-type explosives. U.S. military investigations during World War II included photographic studies of underwater explosions, which required the development of lamps suitable for (1) the illumination of gas bubbles from explosions at different depths and (2) the illumination of relatively small, high-velocity, demolition explosives detonating relatively near the camera. In order to obtain flashes of high intensity and short duration, attention was given to both the surface area of the charge generating the shock wave at a given instant and to the thickness of the argon layer traversed by the shock wave. Both spherical and conical cast pentolite charges were employed.[5] It was found that both the duration and the intensity of the illumination increased with the thickness and the area of the argon gas layer, but details about the methods and results have not been published in the open literature.

The present paper includes microsecond photographs and oscillograph reproductions which show the characteristics of the brief flash of intense light developed by a conical explosive charge in an experimental type of flashlamp used at Eastern Laboratory.

Experimental

Photographs of the argon flashlamp were made with a one-microsecond Rapatronic shutter.[6] The shutter is triggered by the light from the explosion by means of a photoelectric cell (RCA 929) and an adjustable time-delay circuit.

The Rapatronic shutter consists of crossed polarizers between which is a slug of extra-dense flint glass as shown in Fig. 3. The shutter is opened by causing the plane of polarization to rotate in the glass (Faraday effect) by an axial magnetic field.

The 1-μsec exposure is produced when a 24-kv, 0.125-μf capacitor is discharged through a triggered air gap into a nine-turn coil around a slug of extra-dense flint glass 1 in. in diameter. The plane of polarization of the light passing through the glass is rotated by the magnetic field. A doublet camera lens of about 6-in. focal length was used in front of the Rapatronic shutter. Visual focusing was accomplished by rotating one of the polarizers that normally are crossed on opposite ends of the flint glass.

The light-time oscillographic trace was displayed on a Du Mont Type 256A ranging oscillograph, and a photograph was made to record the transient. Light from the argon explosion was allowed to fall on the cathode of an RCA Type 929

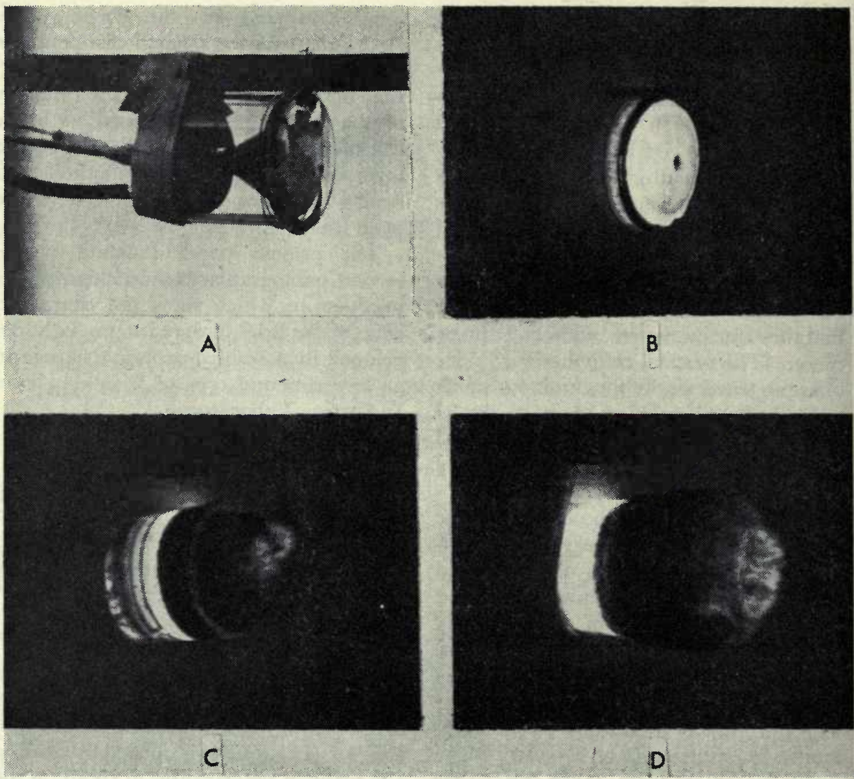

Fig. 1. Explosion of argon flashlamp.

A. Lamp with watch glass 0.5 cm ahead of conical pentolite charge. "Primacord" initiator and argon gas line are at rear.
B. Frontal lamp flash about 0.5 μsec after attaining maximum intensity.
C. Condition about 3 μsec after maximum flash.
D. Condition about 7 μsec after maximum flash.

phototube (S4 cathode) which had a 1000-ohm load resistor and a plate supply of 2000 v. The high plate voltage was necessary to assure that current and light were proportional at the large values of current. The time constant of the output circuit was estimated to be less than 0.1 μsec.

Calibration of light deflection was made by the use of a General Radio Strobolume which produces about 10 million peak beam candlepower.

The explosive flashlamp (Fig. 1A), whose performance is reported in this paper, consisted of a 2-oz conical, cast pentolite (50–50 PETN and TNT) charge within a 2.5-in. diameter glass tube containing argon. The front of the conical charge (contained in a glass funnel) was curved to conform with the curvature of the watch glass sealed over the front of the lamp. The desired 0.5-, 1- or 2-cm spacing for argon between the explosive charge and the watch glass was fixed by using a spacer made from a thin gelatin capsule. The pentolite charge was initiated at the rear apex of the cone by means of the "Primacord" detonating

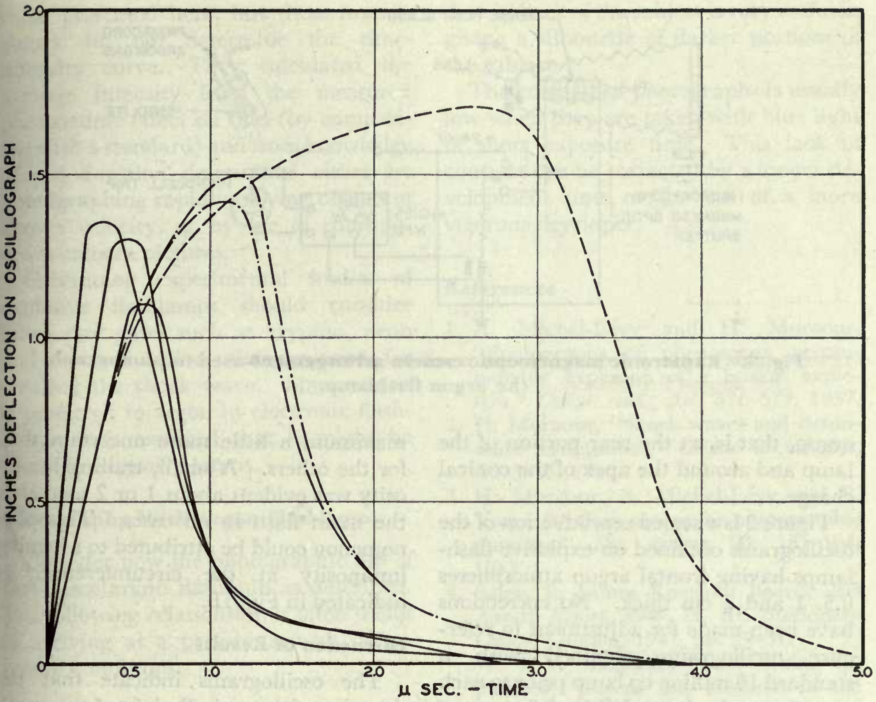

Fig. 2. Luminosity-time curves for argon flashlamps.

Symbol	Thickness of argon layer at front of lamp, cm
———	0.5
—·—	1.0
-----	2.0

fuse which entered the charge through the stem of the funnel. The air in the lamp was flushed out with argon admitted through a tube at the rear of the lamp.

Microsecond Photographs

Figure 1B shows a picture of the argon flashlamp about 0.5 μsec after the maximum intensity of the flash. It may be observed that the luminosity is slightly more intense, and perhaps near the maximum, around the circumference of the face, that is, in the narrow outer region slightly removed from the immediate frontal effect of the explosive. (The front of the lamp had an inside diameter about 0.5 in. greater than that of the explosive charge.) Also evident in the picture is what appears to be a small hole at the center and front of the charge where a 0.5-cm spacer was located. (This spacer was made of cork rather than gelatin.) No light is evident lateral to the direction of propagation of the detonation at the instant of this photograph.

Figures 1C and 1D are pictures of the lamp taken about 3 and 7 μsec, respectively, after the highly actinic flash from the front. In the approximate exposure time of 1 μsec, the hot explosive gases are not sufficiently actinic to appear luminous; and accordingly, the gas cloud pouring out of the front appears black. As the explosion gas spreads out laterally, it obscures the lateral actinic flash in the

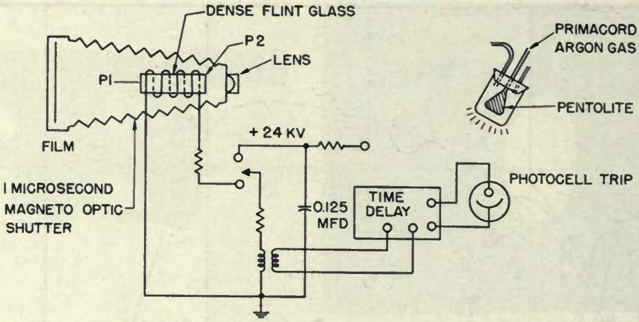

Fig. 3. Rapatronic magnetooptic camera arrangement used to photograph the argon flashlamp.

argon, that is, at the rear portion of the lamp and around the apex of the conical charge.

Figure 2 is a scaled reproduction of the oscillograms obtained on explosive flashlamps having frontal argon atmospheres 0.5, 1 and 2 cm thick. No corrections have been made for adjustment to reference oscillograms obtained with a standard 10 million cp lamp prior to each experimental shot. With 0.5 cm of argon the major portion of the flash was over in 1 μsec or less. The exact shape of the increasing and decreasing luminosity curve could not be ascertained on the recorded scale. The average of the three records for 0.5 cm of argon, by comparison with records of a standard 10 million cp lamp, reveals a peak intensity of about 225 million cp. The flashlamps with 1 cm of argon had a duration of 2 μsec for the maximum luminosity, and the initial rate of increase in luminosity appeared to be approximately that for the 0.5-cm argon layer, but there was a slightly higher maximum. The maximum intensity was 250 million cp. With 2 cm of argon the first and major portion of the luminosity increase was practically as rapid as for the two preceding spacings; however, the duration of the maximum luminosity was about 4 μsec, and the peak intensity was about 300 million cp. The uncertainty of the reference standard for this record makes the maximum a little more uncertain than for the others. A small, trailing luminosity was evident about 1 or 2 μsec after the main flash in all cases. This phenomenon could be attributed to a lagging luminosity at the circumference, as indicated in Fig. 1B.

Discussion of Results

The oscillograms indicate that the duration of the main flash from the argon flashlamp, as measured by the writers, is about 2 μsec for each centimeter of thickness of the argon layer. The maximum intensity is developed after one-half to three-quarters of this time interval has elapsed. The measurements cover argon layers 0.5 to 2 cm thick. The time for development of the maximum intensity probably is related to the time required for the shock wave in the argon to reach the front of the lamp.

The average peak intrinsic brilliancy of the sheet of light-radiating argon gas is calculated by dividing the peak light (225 million cp) by the area (33 sq cm). This value is 6.8 million cp/square centimeter. Flash bombs with larger output would supposedly be of larger argon area. Some care might be required to initiate the flash of all portions of the sheet of gas at the same instant.

The duration and light-intensity data of Muraour et al.[2,3] closely resemble

those presented here, but these investigators did not determine the time-intensity curve. They calculated the average intensity from the measured photoactinic effect on film (by comparison with a standard) and from knowledge of the duration determined either by photographing rapidly moving objects of known velocity, or by use of rotating-drum-camera pictures.

Continuing experimental studies of explosive flashlamps should consider other rare gases such as krypton, neon and xenon as well as other explosives for creating the shock wave. Since xenon is preferred to argon in electronic flashlamps, it is assumed that it might be better in explosive lamps.

Photography With Argon Flashlamp

Consider now the photographic use of the 1-μsec argon flashbulb as described. The following relationship is often useful in arriving at a preliminary set of exposure conditions:

$$DA = \sqrt{KQM}$$

where

D = lamp-to-subject distance in feet
A = aperture of lens
Q = total light output in lumen-seconds
M = reflector factor
K = a constant which depends upon the type of film used and the processing.

For the argon flashlamp without a reflector, $M = 1$ and $Q = 10 \times$ cp-sec $= 2000$ lm-sec (approximately). K is about 0.25 for fast film. Now if A is selected to be about $f/4.5$, then the lamp-to-subject distance, D, can be calculated. D equals about 5 ft.

This result must be used with judgment, depending upon the reflectivity of the subject that is being photographed. Often a sheet of white cardboard immediately back of the subject is very useful in giving a silhouette of darker portions of the subject.

The contrast of photographs is usually low when they are taken with blue light of short exposure time. This lack of contrast can be corrected by a longer development time or the use of a more vigorous developer.

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Integrating-Type Color Densitometer

By FRANK P. HERRNFELD

This color densitometer is for making diffuse density measurements in the blue, green and red, as well as visual bands. This densitometer utilizes an integrating bar for gathering the light, therewith greatly increasing the sensitivity as compared to other methods presently used.

THE REQUIREMENTS for a color densitometer are very similar to those of a black-and-white unit. Enumerated according to importance, they are:

1. reproducibility of readings,
2. simplicity of operation,
3. sufficient range and flexibility,
4. accuracy, and
5. electrical calibration.

Reproducibility of reading was actually the hardest part of our design problem. We found that a stable amplifier alone was not the answer. It calls for rugged mechanical construction, the selection of the proper photoelectric cell, stable optical filters, a color-corrected optical system, and many small features too numerous to mention. When the desired stability was reached, the unit was finished.

Presented on April 24, 1952, at the Society's Convention at Chicago, Ill., by Frank P. Herrnfeld, Frank Herrnfeld Engineering Corp., 5880 Blackwelder St., Culver City, Calif.

Figure 1 shows the optical schematic of the instrument. As light source we use a General Electric 4AT8-34 lamp rated at 8.5 v 4.0 amp. In operation the lamp burns at 7.5 v, has an approximate color temperature of 3000 K, and a life expectancy of 500 hr. In standby condition, the voltage is reduced to 5.0 v. A special socket insures proper electrical contact and placement on the optical axis. Both vertical and horizontal adjustments of the lamp socket are provided.

The condenser lens has full achromatic correction and focuses the filament of the lamp onto an aperture. An interrupter wheel and an infrared absorbing filter are located between the condenser lens and the aperture. The interrupter wheel, driven by a 3600-rpm synchronous motor, modulates the light beam at the rate of 360 cycles/sec, making the use of a stable a-c amplifier possible.

The infrared filter is a Corning No. 9780 $2\frac{1}{2}$-mm thick glass and is always in the light beam. It has the dual purpose of (a) reducing the heat rays reaching

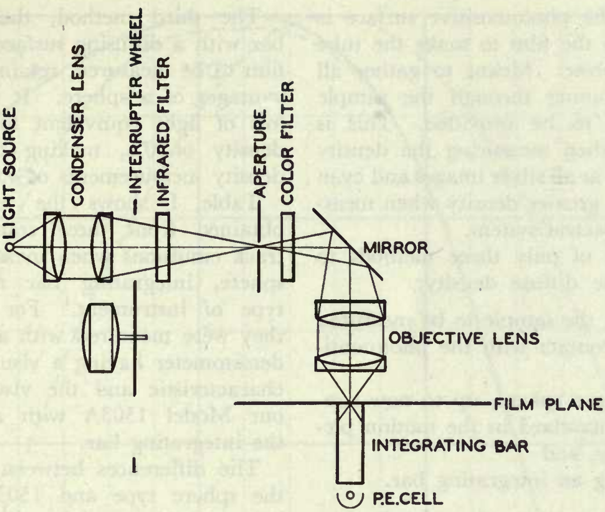

Fig. 1. Optical schematic of the integrating-type color densitometer.

the photosensitive surface of the photoelectric cell in the red and visual setting of the densitometer and (b) eliminating undesirable near-infrared light reaching the photoelectric cell passed by all blue and green filters.

Either of two apertures can be used for making density measurements. One is a round one, illuminating a circle of about $\frac{3}{64}$ in. in diameter at the film plane; the other is rectangular, illuminating a 0.015 by 0.125 in. area. The round aperture is meant for general work and the rectangular one for the measurement of variable-area sound track.

A fully achromatic corrected objective lens focuses the aperture onto the film to be measured. The color and visual filters and a front-surfaced mirror are located between the aperture and the objective lens.

Four filters are mounted in a wheel. A neutral density is mounted with each filter to bring the photoelectric cell output to the same value. This minimizes zero adjustment when going from one color band to another. An integrating bar collects the light passing through the film and delivers it to the photoelectric cell.

In checking all available commercial photoelectric cells, we found only two that lend themselves readily to the measurement of density, namely the RCA 1P42 and 929, or the equivalent in other makes.

We found that the 1P42 had an undesirable lag and color fatigue in the blue and green bands with the amount of light necessary to measure to a color density of 4.0. This can be partially overcome by raising the anode voltage above the ionization potential (18 v).

Raising the anode voltage sufficiently to overcome the fatigue problem raises two others: (1) If any trace of gas is left in the photoelectric cell, the cell will become nonlinear in the low density range when the greatest amount of light is present. (2) It will raise the dark current which means more noise, reducing the small margin between signal to noise in the high density range.

The 929 photoelectric cell has a greater output for a given light input, and does not seem to suffer from the above-mentioned shortcomings of the

1P42, but the photosensitive surface is too far from the film to make the tube a good receiver. Means to gather all the light coming through the sample tested have to be provided. This is important when measuring the density of negatives, as all silver images and cyan dyes show a greater density when measured in a spectral system.

We know of only three methods to measure true diffuse density:

1. placing the sample to be measured directly in contact with the photosensitive circuit,
2. utilizing a sphere, up to now considered the standard in the motion picture industry, and
3. utilizing an integrating bar.

The first method, theoretically the most simple, is nearly impossible in actual practice. The second method, excellent in black-and-white measurements, introduces too much loss into the system. Depending upon the method of coating and the size of the sphere, a loss of light equivalent to inserting a density between 1.3 and 1.5 is the minimum obtainable in practice. Adding this loss to the insertion loss of the optical filters will restrict any instrument using a design similar to ours to a maximum density range of 3.0.

The third method, the integrating bar with a diffusing surface toward the film to be measured, retains all the advantages of a sphere. It introduces a loss of light equivalent to inserting a density of 0.6, making diffuse color density measurements of 4.0 possible.

Table I shows the measurements obtained from three common sound track emulsions when measured with a sphere, integrating bar and spectral type of instrument. For comparison they were measured with a sphere-type densitometer having a visual-type color characteristic and the visual filter on our Model 1503A with and without the integrating bar.

The differences between readings of the sphere type and 1503A with the integrating bar are due to difference in spectral sensitivity of the two instruments.

Figure 2 shows the spectral distribution of the light source and the visual filter with this light source compared to an average eye characteristic.

Figure 3 shows the spectral distribution of the three combination color filters with the light source shown in Fig. 2.

As mentioned before, the Corning No. 9780 infrared absorbing filter is

Table I. Comparison Test of Three Common Sound-Track Emulsions (using Pathé 2B Sensitometer).

	E.K. 5373, 4-min dev.			DuPont 836, 5-min dev.			DuPont 831, 9-min dev.		
Step	RA-1100B	1503A	1503A-S	RA-1100B	1503A	1503A-S	RA-1100B	1503A	1503A-S
1	0.04	0.03	0.05	0.05	0.05	0.07	0.09	0.09	0.13
3	0.06	0.05	0.08	0.06	0.06	0.09	0.11	0.12	0.15
5	0.11	0.09	0.16	0.12	0.10	0.19	0.18	0.19	0.26
7	0.19	0.17	0.29	0.20	0.17	0.31	0.40	0.44	0.56
9	0.33	0.28	0.48	0.33	0.29	0.50	1.00	1.08	1.37
11	0.49	0.46	0.71	0.53	0.48	0.75	2.05	2.16	2.63
13	0.69	0.66	0.95	0.77	0.71	1.06	3.18	3.28	3.75
15	0.90	0.88	1.21	1.07	1.00	1.43	3.87	3.97	4.+
17	1.12	1.10	1.47	1.39	1.33	1.80			
19	1.31	1.31	1.67	1.71	1.67	2.13			
21	1.45	1.47	1.81	1.94	1.95	2.38			
Gamma	0.69	0.69	0.88	0.96	0.96	1.17	3.66	3.66	4.68
Q	1.27			1.22			1.28		

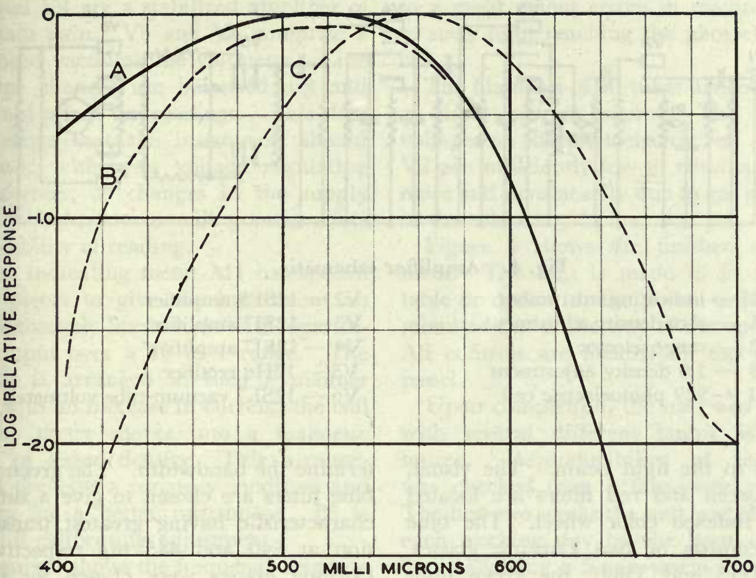

Fig. 2. Response of light source visual filter and eye. A: tungsten 2780 K + Corning 9780 + 929 photoelectric cell; B: light source + Corning 3389; C: average human eye.

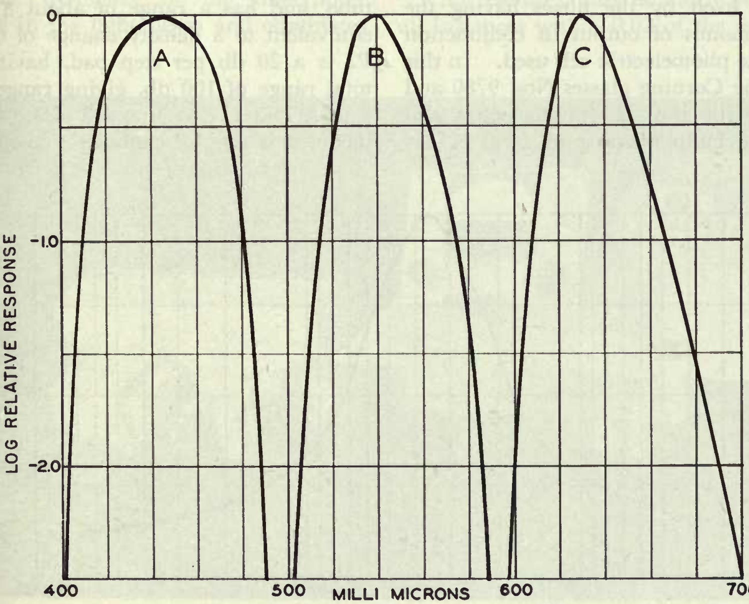

Fig. 3. Response of color filters. A: light source + Corning 3389 + 5113; B: light source + Corning 3486 + 4010; C: light source + Corning 2408.

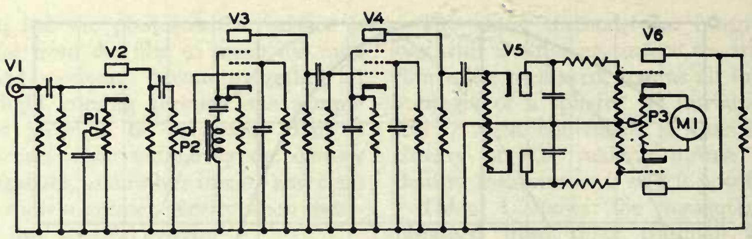

Fig. 4. Amplifier schematic.

M1 — indicating instrument
P1 — zero density adjustment
P2 — range selector
P3 — 1.0 density adjustment
V1 — 929 photoelectric cell
V2 — 12SF5 amplifier
V3 — 12SJ7 amplifier
V4 — 12SJ7 amplifier
V5 — 12H6 rectifier
V6 — 12SL7 vacuum-tube voltmeter

always in the light beam. The visual, blue, green and red filters are located in an indexed color wheel. The blue filter consists of two Corning glasses, Nos. 5113 and 3389; the green filter of two Corning glasses, Nos. 4010 and 3486; and the red of one Corning glass No. 2408.

The minimum bandwidth of the system is fixed by the filters having the least amount of output in conjunction with the photoelectric cell used. In this case, the Corning glasses Nos. 9780 and 2408, with the 929 photoelectric cell and the lamp burning at 3000 K determine the bandwidth. The green and blue filters are chosen to give a similar characteristic having greatest transmission at 540 and 445 mμ respectively. Corning glasses were chosen for their greater permanence.

Figure 4 shows the electrical schematic of the amplifier. The zero adjustment is in the cathode of V2, the first amplifier tube, and has a range of about 8 db, equivalent to a density change of 0.40. P2 is a 20 db per step pad, having a total range of 100 db, giving ranges of 0 to 1, 1 to 2, 2 to 3, and 3 to 4. Also included is the 1.0 calibration position.

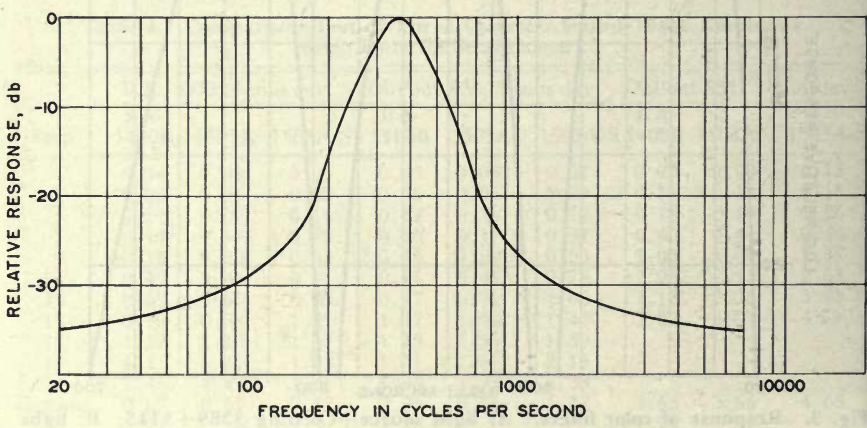

Fig. 5. Frequency response of amplifier.

V3 and V4 are a stabilized amplifier of constant gain. V5 and V6 comprise a balanced vacuum-tube voltmeter. Line voltage changes are balanced out and will not affect the readings. This does not mean that the instrument should be used without a voltage regulating transformer, as changes in the supply for the light source will greatly affect the stability of reading.

The indicating meter M1 has special pole pieces to give the instrument an approximately linear scale with logarithmic input over a 10 to 1 range. The circuit is arranged in such a manner that with an increase in current, the coil of the meter moves into a magnetic field of lesser density. This arrangement prevents a runaway condition and makes for a better instrument. P3 is the 1.0 calibrating adjustment.

Figure 5 shows the frequency response of the amplifier section V3 and V4. This characteristic is caused by the tuned circuit in the cathode circuit of V3. The peak transmission corresponds to the frequency of the interrupter wheel in the light beam and eliminates to a great extent errors in reading due to stray light reaching the photoelectric cell.

The filaments of all tubes are fed from a direct current source. The anode voltages on the photoelectric cell and of V2 are sufficiently low to eliminate any noise and nonlinearity due to gas present in the tubes.

Figure 6 shows the finished instrument. The unit is made to fit into a table or desk with the power unit to be mounted out of the way of the operator. All controls are located on top of the panel.

Upon completion, the unit was tested with several different lamps as light source. Reproducibility of readings was checked over a four-week period. The first two weeks the unit was checked each working day by the hour on the hour, allowing a 5-min warm-up period before making a reading. The instrument was shut off after each test. The latter two weeks the instrument was left on continuously.

The readings thus obtained were in all instances within 0.02 of the original

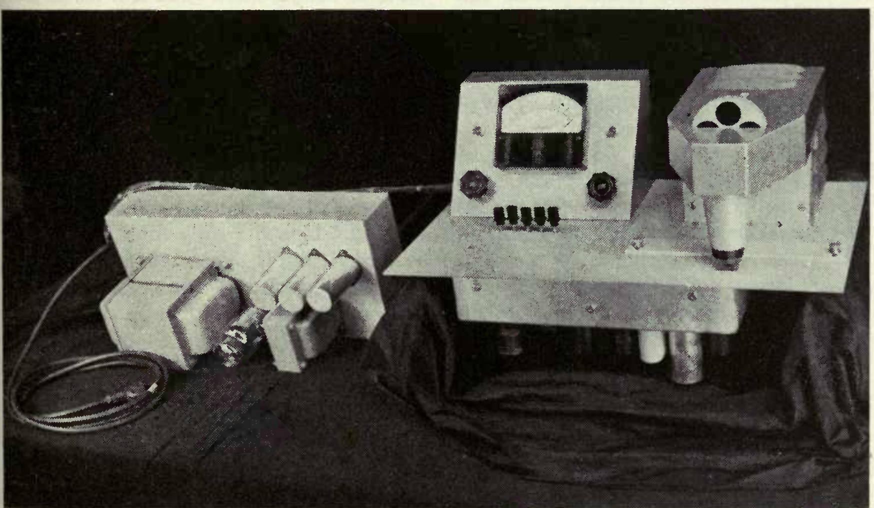

Fig. 6. Model 1503A color densitometer.

measurement. Aging or changing of the lamp had no influence on the readings.

The different density ranges and calibrations are selected by five push buttons plainly marked in front of the meter case. The film strip is held in a step-calibrated carriage, allowing easy selection of different tablet steps. After a 15-min warm-up period, recalibration is seldom necessary.

The maximum range of the instrument is sufficient for all measurements encountered in the motion picture industry. Selection of the proper filter is simple and sure. All readings taken are diffuse readings and no change of location of the photoelectric cell is necessary.

The absolute accuracy of reading, compared to a sphere-type and visual-type instrument, is sufficiently close for all purposes for which the instrument may be used. A 20-db signal-to-noise ratio on its highest reading, at a density of 4.2, guarantees accuracy over the complete range. The bandwidth of each of the three color filters is sufficiently narrow, and the suppression of all unwanted radiation sufficient to give an insertion loss of more than the equivalent of a density of 7.0 to white light when any two of the three filters are placed into the light beam at the same time.

The instrument is calibrated electrically. The accuracy thus obtained is only a function of how much care has been taken in doing it.

Several of these instruments are now in commercial service and have given consistent results.

Transmission Color in Camera Lenses

By PHILIP T. SCHARF

The color contribution of a lens has been defined in terms of its transmittance density at 400 and 700 mμ. It is proposed that the difference in the densities at these two wavelengths be held to 0.05 ± .03 for motion picture camera lenses; 0.05 ±.05 for other camera lenses. To prevent the curve from being too highly inflected between these two points an additional requirement is that the minimum density between 400 and 700 mμ differ from the density at 700 mμ by no more than 0.04 density units. It has been found convenient to describe quantitatively the glass absorption by a term called "color index." A simple method of determining the combined effect of glass absorption and surface coating is outlined.

THERE HAS BEEN considerable interest in recent years in the subject of camera lens transmission. Prior to the advent of antireflecting coatings it was not unheard of to have light losses amounting to as much as 50%. With present-day coated lenses, however, losses greater than 10% are seldom encountered. In terms of lens aperture this means that the loss of light with a coated lens does not exceed $\frac{1}{6}$ of a stop. While there may still be reason for occasionally investigating the overall light loss of a coated lens, other variables in the photographic process will generally mask this $\frac{1}{6}$ of a stop. On the other hand, the color of the light transmitted by camera lenses has caused much less interest, but in present-day practices it is probably more important than the overall white light transmittance. The increased interest in color photography is responsible for the importance of this color factor. Interchangeable lenses on cine cameras have made it possible for the photographer to perform a very critical test for the uniformity of color in his lenses. In this case the same scene, the same film, and the same processing variables are maintained while only the lens is varied. This means that if the same exposure is used, the only variable is the color of the lens. We wish to center our attention on this subject of color variations occurring in lenses, and to investigate methods of minimizing this variation.

There are two distinct factors contributing to the color of a lens. The first is the color of the glass itself. This

A contribution submitted June 17, 1952, by Philip T. Scharf, Process Development Dept., Hawk-Eye Works, Eastman Kodak Co., Rochester, N.Y.

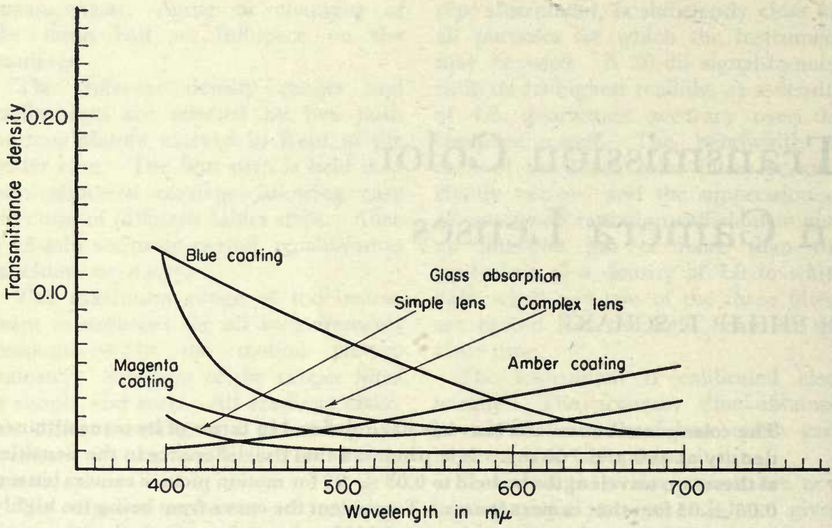

Fig. 1. Transmittance losses from glass absorption and coated surface reflection.

color, generally yellowish, is caused by the ultraviolet absorption band of glass. Modern experiments have proven that in most optical glasses the visual color is a function of impurities present in the raw materials. At some future date, production quantities of all the common optical glasses may be available free of color. Until then we must learn how to use existing glasses. We have made a fairly extensive study of all the commonly used glasses from many sources. Two important findings that have come from this study are that there is a considerable difference between manufacturers and that the sources supplying color-free glasses appear to be able to maintain their quality. These findings have enabled us to put a certain degree of control over this first source of color in a lens.

It is generally recognized that the antireflecting coatings impart a degree of color to the transmitted light. If we observe the light reflected from different thicknesses of these coating films we see that the thinner films are yellowish or amber, the thicker ones bluish, with magenta films lying in between. The yellow reflection means that less blue light is reflected than red or green which in turn can be interpreted as meaning that more blue light is transmitted. Likewise the magenta coating means more green light is transmitted and the blue coating means more yellow light is transmitted. Since coatings do transmit light selectively we have here the second contributing source of color in the lens. An advantage can obviously be gained if we can get these two factors to cancel one another. Figure 1 is a plot of the two color-contributing factors in terms of wavelength and transmittance density. It can be seen that the curve shapes are essentially different so that complete cancellation cannot be hoped for, but a good approximation is possible. Simple lenses having little glass absorption will need less color compensation from the coatings than the more complex lenses.

The complete color specification for a lens is given by its spectrophotometric curve as shown in Fig. 2. However, a single quantity would be convenient to use in expressing the varying degrees of

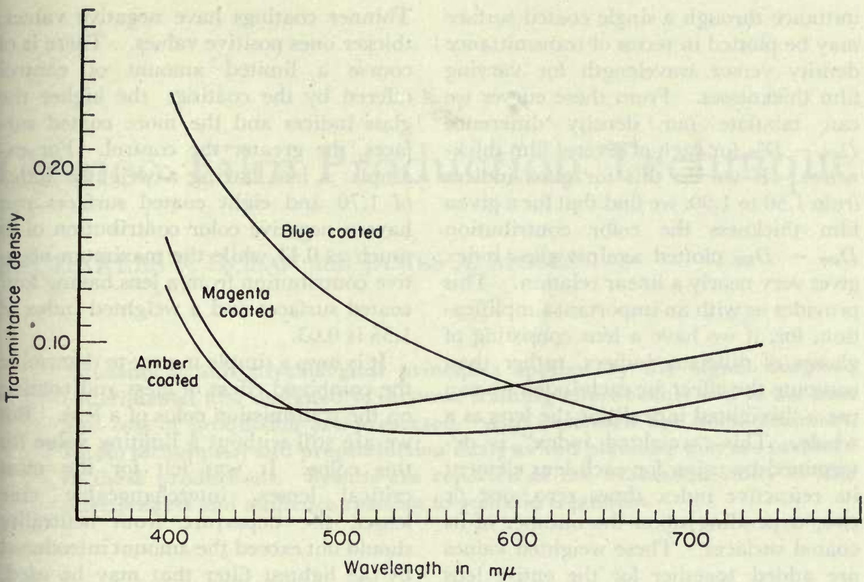

Fig. 2. Spectral transmittance of coated lenses.

color. It was decided that since we are dealing with more or less similar curves the difference in characteristics at two points of the spectrum would suffice to specify the color. From the standpoint of measurement accuracy, wavelengths should be chosen to give as large a density difference as possible. On the other hand the limits of sensitivity of color films are a consideration. As a compromise 400 and 700 mμ were chosen. Since transmittance densities are additive we shall speak of the color contribution in terms of the transmittance density difference at 400 and 700 mμ. That is, $D_{400} - D_{700}$ equals the color contribution.

Having defined this quantity it will be convenient to evaluate the two sources of color in terms of this quantity. To this end we have defined a term known as "color index" for a description of the color of a piece of glass.

If t is the glass thickness in millimeters,

$$\text{Color Index} = \frac{D_{400} - D_{700}}{t}.$$

The glasses most free of color have values from 0 to 0.0005. The worst glasses for color have indices of 0.0300. When using color index as a manufacturing tolerance it has been convenient to multiply by a factor of 10^4 to give integral values 0–300.

To compute the glass contribution we have merely to multiply the lens thicknesses in millimeters by the color index of the glass from which the lenses were made. The use of densities instead of per cent transmittance permits adding the values from each lens element. This gives us a simple method of determining quantitatively the effect of the glass absorption, and now we turn to the coating problem.

The color arising from the film coating is a function of three variables — the index of the glass, the number of coated surfaces, and the thickness of the coated film. The first two are fixed in the design of a lens so that we have only the last variable left for control. The trans-

mittance through a single coated surface may be plotted in terms of transmittance density versus wavelength for varying film thicknesses. From these curves we can tabulate our density difference $D_{400} - D_{700}$ for each of several film thicknesses. If we do this for glass indices from 1.50 to 1.90, we find that for a given film thickness the color contribution $D_{400} - D_{700}$ plotted against glass index gives very nearly a linear relation. This provides us with an important simplification, for, if we have a lens consisting of glasses of differing indices, rather than compute the effect for each index we can use a "weighted index" for the lens as a whole. This "weighted index" is determined by using for each lens element its refractive index times zero, one or two, depending upon the number of its coated surfaces. These weighted values are added together for the entire lens and divided by the sum of the weightings, that is, the total number of coated surfaces. We now use a table having as entries the film thickness and the weighted index. The body of the table consists of the color contributions from the coated glass surface. We have found it convenient to have a table for four, six and eight coated surfaces. The dispersion of glass has been taken into account in setting up the tables, although this is a secondary effect.

The color contribution arising from glass absorption is always a positive quantity, i.e., the $D_{400} - D_{700}$ is always greater than zero since the glass transmittance density in the blue region is greater than in the red. The contribution from the coating, however, takes on negative values as well as positive values and this is what enables us to control the transmission color of the lens. A coating having its minimum reflection at about 500 mμ has a zero value for the term $D_{400} - D_{700}$ regardless of glass index. Thinner coatings have negative values, thicker ones positive values. There is of course a limited amount of control offered by the coating; the higher the glass indices and the more coated surfaces, the greater the control. For example: a lens having a weighted index of 1.70 and eight coated surfaces can have a negative color contribution of as much as 0.11 while the maximum negative contribution from a lens having four coated surfaces and a weighted index of 1.55 is 0.03.

It is now a simple matter to determine the combined effect of glass and coating on the transmission color of a lens. But we are still without a limiting value for this color. It was felt for the most critical lenses, interchangeable cine lenses, the departure from neutrality should not exceed the amount introduced by the lightest filter that may be used. In the Kodak Wratten series of Light Balancing Filters the lightest is the No. 81. It has a value for $D_{400} - D_{700}$ of 0.08. It was found that for the simplest cine lenses 0.02 represented the minimum color contribution. This range 0.02 to 0.08 was therefore taken as a reasonable range of color contribution values for cine lenses. Other camera lenses being less critical for color could have the range 0.0 to 0.10. To avoid any possibility of the spectral curves becoming too highly inflected between 400 and 700 mμ, it is suggested that the expression $D_{700} - D_{\text{minimum}}$ have a maximum value of 0.04, that is, the density at 700 mμ must be within 0.04 of the minimum density wherever it is.

There will of course be camera lenses which cannot be made to meet these color specifications. Large aerial lenses are examples, but in such cases we do not ordinarily have rigid requirements for neutral transmission.

Cameo Film Production Technique

By CHARLES F. HOBAN and JAMES A. MOSES

Educational and psychological principles applied by the Signal Corps in experimental film designed to increase training effectiveness and to cut time and cost of production are presented. Also described are story treatment, studio techniques, and preproduction analysis and planning that are involved in these productions. Results are reported of the evaluation study of film effectiveness and audience reaction to scenario treatment.

NONTHEATRICAL film producers are under increasing pressure to do two things which appear contradictory and irreconcilable. There is the demand that training, information and public-relations films be produced more rapidly and more economically. At the same time, there is a demand that the effectiveness of films be increased. Under conventional production procedures, films cost too much and take too long to produce. When produced, films frequently do not accomplish their purpose as effectively as sponsors hope and have a right to expect. To film producers who equate "film quality" with film effectiveness, it seems impossible to make better films and, at the same time, reduce the time and cost of production.

In this paper we will describe some applications of educational and psychological principles of film influence to story treatment and studio methods being developed by the Signal Corps to improve training effectiveness and reduce time and cost of production. Use of these procedures will be illustrated in the experimentally produced Army training film, TF 11-1752 *How to Operate the Army 16mm Sound Projector Set*. There is some reason to believe that the basic educational *principles* applied to the film on operation of the projector set are not necessarily limited in application to this particular film or to training films of the "nuts and bolts" type. However, we are not concerned with a specific technique used in the experiment. It just happened that the particular production technique fitted the subject and accomplished the desired results. Under no circumstances should the production technique used in this film be construed as a "blueprint" for film productions in general.

Two sources of inspiration for improved film production procedures and techniques are currently available. *For one thing*, the possibility of low-cost, rapid program production has been explored extensively by commercial television and

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by Lt. Col. Charles F. Hoban and James A. Moses, Army Pictorial Service Div., Office of the Chief Signal Officer, Dept. of the Army, Washington 25, D.C.

by the Navy's Special Devices Center at Port Washington, N.Y. The affinity of television to radio, by way of establishment of television studios and networks in association with radio studios and networks, brought into television a group of artists, craftsmen and technicians not too familiar with motion picture production and motion picture studio practice. Partly because of studio and small-screen limitations, and partly because of fresh talent in the television industry, television has changed the format of video presentation and revived many techniques successfully used in the past in military training and other nontheatrical films.

The second influence on film production methods and techniques, particularly in training and informational films, is the growing body of research data on factors which increase the instructional effectiveness of motion pictures. On the whole, this research has tended to verify and emphasize the applicability to motion pictures of well-known instructional procedures, and to demonstrate that the training and informational effectiveness of films is measurably increased when instructional procedures are incorporated into film production.

This emphasis on instructional techniques in training and informational films is almost as unwelcome to the professional film producer as is the emphasis of the television producer on production shortcuts and simplified background and sets. Teachers are, as J. E. Morpurgo says in *The Impact of America on European Culture*, "the depressed class in America's predominantly commercial society." Instruction techniques are associated with teachers. Submergence of teachers in the American value system submerges

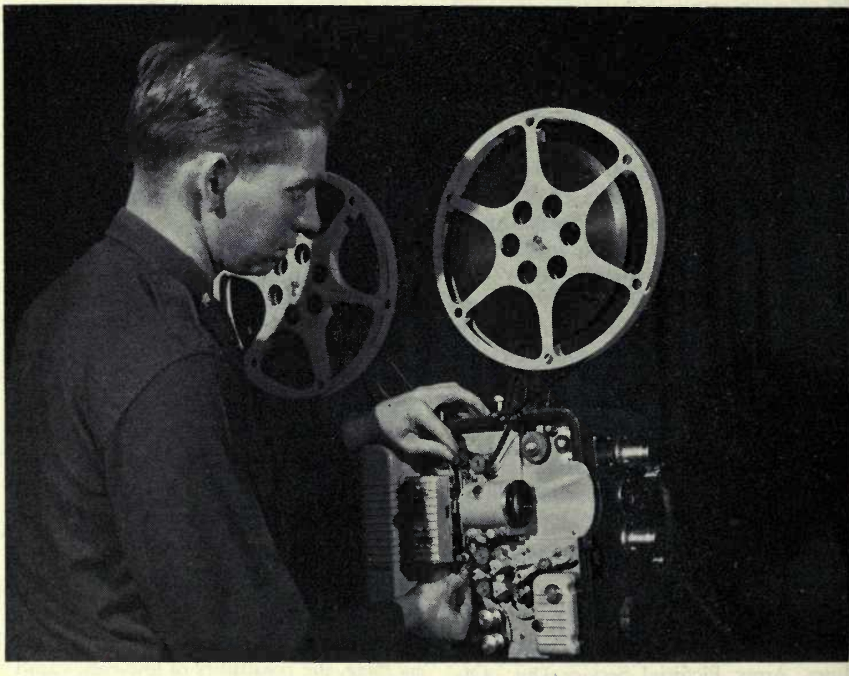

Fig. 1. "... occasionally Jim steps out of his role, and for a moment, is the master of both the machine and of the practical aspects of the theory."

the prestige of instructional techniques identified with teachers. However, the relationship of scientific research in nuclear physics to the engineering development of the atomic bomb had the indirect effect of raising the status of scientific research in the American value system. The soft-spoken professor, with umbrella and academic detachment, achieved sudden and unprecedented status. Consequently, academic research on motion picture influences and on factors which increase effectiveness of motion pictures in training and information has today achieved a prestige and a measure of governmental support completely unknown before World War II.

The net effect of instructional film research has been the renewed emphasis in nontheatrical film production on application of these techniques. Where teachers failed to influence producers of teaching films the research technician, working under controlled laboratory conditions and employing such terms as "audience participation" to describe what was formerly referred to as "reciting" and "classroom drill," has succeeded in raising by halo effect the status of instructional techniques as a recognized element of training and informational films.

Our discussion of the relationship of these two factors, i.e., (1) instructional film research findings and (2) television emphasis on rapid, low-cost programming, to current trends and innovations in training and informational film production will be organized around three topics: first, *story treatment;* second, *studio methods;* and third, *preproduction analysis and planning*.

I. Story Treatment

There are several things about the story treatment of the Signal Corps' experimental film, TF 11-1752 *How to Operate the Army 16mm Sound Projector Set*, that were intended to serve the dual purpose of cutting production time and cost and increasing training effectiveness of the film. First, we incorporated into this film a number of instructional principles which have firm foundation in current theory of educational and social psychology. One such principle, long stressed by William A. Brownell, distinguished educational psychologist, is that instructional materials, to be instructionally effective, must be produced so as to reflect *process of learning*, not simply the *product of learning*.

Following this dictum, story treatment of TF 11-1752 was developed so as to teach operation of the projector in the way trainees actually behave in learning this operation, and not exclusively to demonstrate the way projectionists behave after they have learned and practiced their lessons.

To do this, two characters were created: Jim, the trainee; and the off-stage voice of the expert. This provided two models for the audience: the one who could be imitated immediately, and the other who represented a model of future performance. The technique of the off-stage voice had been used previously by the Signal Corps in production at the end of World War II of a series of films on map reading.

Jim, the trainee, was carefully developed in the scenario and carefully cast. His ability to handle the projector set, clean it and operate it is established on a level slightly above that of the complete novice, but somewhat below that of the expert. Occasionally, in the picture, Jim steps out of his role and for a moment is master both of the machine and of the practical aspects of the theory. But, characteristically, Jim is the pleasantly alert and occasionally forgetful American young man, temporarily in Army uniform, who prides himself on his ability to master machines and complicated equipment.

Jim is objectified on the screen. He can be seen and heard and his performance can be carefully observed and easily

evaluated by the trainee audience. The off-stage voice, on the other hand, is transparent. The audience is free to project physical characteristics, rank, occupation and status into the off-stage voice. His competence as an expert, however, is thoroughly established in the film — that, and no more. Preliminary analysis of audience reaction to this film, under actual classroom conditions, indicates that the off-stage voice is dominant in the film, and that the audience projects more desirable qualities into this unseen character than to Jim, who appears in almost every scene.

In developing the story treatment into which the characters of the trainee and the experts are interwoven, two additional principles of instruction were introduced. To be effective as a teaching device, it was essential that the film have a *psychological organization* rather than a purely logical organization. Experience in projectionist training indicates an impatience on the part of the trainee with postponement of practice in the actual threading and operating of the projector, and lack of readiness for instruction in assembly, inspection, preventive maintenance, nomenclature and disassembly, until the point of operation has been passed. Logical organization of the treatment of the subject, based upon identification and explanation of component parts and on time sequence of operations, would, it was assumed, go contrary to the readiness of the audience for instruction. The law of readiness is an old concept in educational psychology, and a valid one. Deliberately to proceed in film instruction contrary to this law would, at least theoretically, reduce the teaching effectiveness of the film. The problem of logical versus psychological organization of subject presentation was solved, in part, by backing into the subject. This was done by opening the film with Jim, the trainee, preparing to place the full reel of film on the feed arm, and to thread and operate the projector.

Another instructional principle introduced into the story treatment was that of *interrupted action*. An audience has a tendency, amounting to a compulsion, to complete an action once the action has been started. Interruption and suspension of action before completion, or omission of a part of a film obviously included in the original version, tends to create a tension in the audience which can be satisfactorily discharged by completion of the initiated action or exhibition of the omitted part. This tendency is well documented, and is closely related to the well-known psychological phenomenon of closure. The problem in film production is to apply the principle of interrupted action to story treatment so that it operates to increase the involvement of the audience in the subject of the film and thereby increase learning and retention.

The off-stage voice was used to accomplish this intent. Actually, the off-stage voice served several purposes. As already indicated, it constituted a transparent model of expert knowledge and competence in operation of the projector set. Second, the off-stage voice, by remaining off-stage, permitted individual visual concentration on Jim, the trainee, and on the projector set. Third, the off-stage voice was used as a device, a gimmick, if you will, for repetition and emphasis of the important teaching points of the film. Finally, the off-stage voice was used as a device for interrupting Jim's progress in threading and operating the projector in order to insure and insist on prethreading and preoperating checks, cleaning and projector adjustment. Preliminary analysis of field evaluations of this film, to which reference has already been made, indicates that, while the interruptions may have annoyed the audience, the teaching effectiveness of the sequences accompanying the interruptions appears to have been strengthened.

Two other characters were used —

one, another off-stage voice somewhere in the gallery; the other, a clearly visual WAC. The Voice-from-the-Gallery had a twofold purpose. The less important of these was that of a gimmick used to sustain interest in the film by the introduction of contrast and disharmony.

Generally speaking, nontheatrical film producers act on the premise that it is impossible to maintain audience interest for thirty-odd minutes in a film dealing with the operation and care of a piece of technical equipment such as the JAN projector set. This premise sometimes approximates an article of credo in the trade. Use of the Voice-from-the-Gallery was a nod to this credo and a form of insurance against possible waning interest in the audience. The more important reason for use of the Voice-from-the-Gallery was to simulate audience participation in the demonstration and explanation of the projector set. The Voice-from-the-Gallery raised the kinds of questions which, it was anticipated, would exist in the mind of the audience. In this way, the Voice-from-the-Gallery acted as audience protagonist during the film showing. It was conceived as somewhat of a character and no attempt was made to disguise this conception in the film. Approximately 10% of the projectionist trainees resent this character, but it is generally admitted that he raised questions pertinent to the subject of the film.

The Voice-from-the-Gallery was also used as a device for emphasizing two facts which needed to be established for the audience: (1) the existence, importance and usefulness of mimeographed directions on operation of the projector; and (2) the concept of the film as a specific training aid, rather than a com-

Fig. 2. "...the off-stage voice was used as a device for interrupting Jim's progress and for repetition and emphasis of the important teaching points of the film.

plete course of instruction on operation of the JAN projector set.

In shooting the picture, the Voice-from-the-Gallery was recorded during the noon-hour lull of one day of production. The off-stage voice, however, was recorded in dialogue on the set simultaneous with the live action. This procedure was intended to increase the spontaneity and realism of the running dialogue between Jim and his off-stage mentor.

The fourth character in the film was the WAC. The purpose of the WAC sequence was to poke fun at the complaints about the weight of the complete projector set. The facts are that the JAN projection equipment is heavy and consists of three pieces. There is no point in pretending in the film that these facts do not exist. The alternative is to attempt to reduce possible adverse reaction to these factors. Contrary to some expressed audience reaction, the WAC is not a lady wrestler. Her facility in carrying the projector and amplifier was actually a facility in carrying an empty projector and amplifier case supplied by the prop department.

The WAC sequence is pure corn. There is no objection to corn in an instructional film if it is useful as a means of accomplishing one of the purposes for which the film is made. The valid objection to the use of corn in a training or informational film is the use of corn for its own sake. In general, the audience of projectionist trainees sees the WAC as a device for combating gripes or simply as a device to leave the audience in a good mood.

Several other instructional techniques, the importance of which has been indicated in film research, were incorporated into the film. The use of *repetition* has previously been indicated. The threading of the projector was shown three times. The use of the lens lever was repeatedly demonstrated. Care in removal of the aperture and pressure plates was repeated. *Slow rate of development* was a must in acting, shooting and editing. The instruction in the film moves at a rate geared to a learning audience. Except in a few instances, *subjective camera angle* was employed, and *extreme close-ups* were extensively used. Repetition, slow rate of development and subjective camera angle have been shown in experimental film research to measurably improve instructional effectiveness of films demonstrating manual operations.

Basic to story treatment and scenario of this film was the concept of *conflict* and the importance of conflict in the learning process. If there are no obstacles to be overcome, or no need to overcome obstacles, there is little or no need to learn. Hence the introduction of the concept of conflict into the story treatment. Throughout the film, there is the continuing problem of whether Jim will triumph over the machine or the machine over Jim. In counterpoint, is the implicit and friendly conflict between Jim and the off-stage voice. These sorts of conflict prevail and are accepted as challenges in the American culture.

The general principle of story treatment of instructional films underlying the Signal Corps' use of the conflict concept in the experimental film is the desirability, if not actual necessity, of taking into account those *characteristics of the culture* of a society which are dominant in social behavior, and to incorporate these cultural characteristics into films in order to increase the audience acceptance of the informational and instructional content of the film. Perhaps more than we realize, these cultural characteristics may be extremely important to the dynamics of film influence and film realism than elaborate backgrounds, establishing sequences and the polished perfection of studio props.

Throughout the story treatment and scenario preparation of TF 11-1752 was the psychologically respectable but frequently ignored idea that, since instruction has to do with learning, and learning

is done by the learner, *the subject must be approached from the point of view of the learner.* Training, informational and propaganda films are often produced from exactly the opposite point of view. They consist of the expert presentation of a subject by an expert on the subject on the assumption that film is some sort of magic medium of transmission of wisdom from the wise to the ignorant.

II. Studio Techniques

The term Cameo Technique is used here to describe some of the studio techniques applied to the experimental film, TF 11-1752, in order (1) to cut time and cost of production and (2) to increase teaching effectiveness of the film. As we all know, a cameo is a stone on which a character is carved in relief. The TV Cameo Theater is so named, presumably, because of the exclusive employment of the cameo technique in video presentation.

This technique consists of the omission of background in the studio set, the inclusion of only essential foreground objects and characters, and the spot lighting of these objects and character action. Picturewise, these are suspended in an enveloping blackness. Nothing is visible to distract attention from the essential characters and objects around which the story treatment is built. Use of this technique served the twin purpose of simplifying studio production and of increasing audience concentration on the essentials of the subject.

In the production of the Army's film *How to Operate the Army's 16mm Sound Projector Set*, only one set was used, the

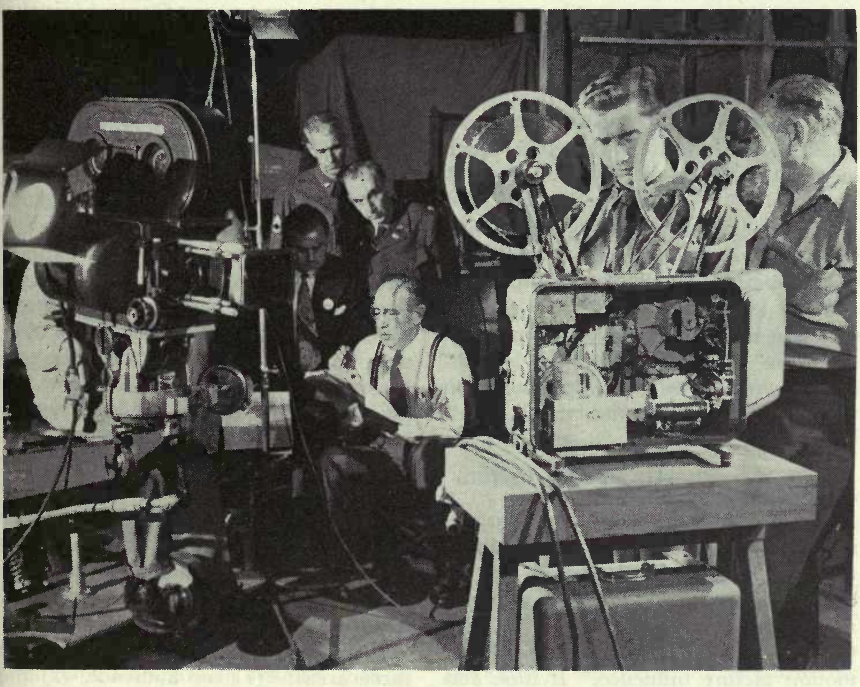

Fig. 3. "In the production of the film on *How to Operate the Army's 16mm Sound Projector* only one set was used."

walls of which were draped with gray curtains, hanging in folds and following the L-shaped pattern of the set. With this L-shaped set, draped in such a manner, only the screen, the speaker, the projector and amplifier, the table for the spare parts, and the actor required lighting, and these by spots. The lack of background permitted easy movement of prop equipments for front, back and side views; long shots, close-ups, reversal shots, and relative constancy of camera position and spot-light location and regulation. The draped L-set (1) facilitated the rapid shooting of the picture and (2) reduced the cost of set construction and lowered personnel requirements for electricians and grips.

The general principle illustrated by the Cameo Technique as used in the Army's TF 11-1752, is that *foreground, not background, is the focus of action and attention in a motion picture.* The context essential to perception of meaning is shifted from more or less accidental and purely situational settings, which vary in any given operation, to a simple presentation of crucial cues, consisting of meaningful and irreducible wholes in which elements, parts and fragments are embedded.

Motion pictures have traditionally been based *de facto* on a theory of fidelity of representation. It has been assumed that an audience can perceive the full meaning of a picture only when a full clutter of all visual background is faithfully photographed and reproduced on the screen. Among other things, intellectual activity consists of abstracting essential meanings from the clutter of context and situation. Where the purpose of a film is to facilitate this intellectual process of abstracting and analyzing essential meanings and essential operations out of their contextual clutter, it seems reasonable that the *principle* underlying the Cameo Technique actually facilitates the desired audience response. The usual studio treatment, based on an exaggerated fidelity-of-representation theory, may interfere with or at least not substantially contribute to this end.

Another aspect of studio and story treatment of TF 11-1752 which relates to the ideas back of the Cameo Technique is elimination of the conventional build-up in the film of the introduction to the subject. For the most part, elaborate establishment of situations in order to obtain audience rapport is unnecessary, costly and time consuming for an audience reasonably sophisticated in the subject.

In TF 11-1752, the film opened with the projector set assembled and the projectionist preparing to thread the film through the projector. The film is intended for use in projectionist training programs for military trainees, all of whom have completed basic training and presumably are aware that military training is essential to successful military operations and to personal survival, and that training films are *good* training aids; also, that the effectiveness of any film presentation is greatly enhanced by *good* projection of the film.

III. Preproduction Analysis and Planning

It is apparent that story, scenario and studio treatment of the Army's training film, TF 11-1752, involved both a great deal of preproduction analysis and planning, and a working familiarity with theory and research on the dynamics of motion picture influence. If time and cost of production were to be cut, increased emphasis on preproduction analysis and planning was required. If the effectiveness as a training and informational film was to be increased, then the principles of effective instruction had to be incorporated.

Preproduction analysis was needed in three areas: (1) the audience, (2) the objectives of the film, and (3) the situation of film use. In every motion pic-

ture situation, there are always two, not just one, important parts: the audience and the film. We started with the *audience.*

There were two things which we were required to know about the audience before we could effectively plan the film to instruct, inform or otherwise influence the audience: First, who was the intended audience and what was it like? Second, what did the prospective audience already know about the subject?

The anticipated audiences of TF 11-1752 consisted of military trainees — a cross section of American youth. They are motivated by the typical American drive to "get the job over with." Army service is accepted as something necessary to get the job over with, and Army training is part of the job. Eight out of ten of the draftees in today's Army have received some high school education. Fifty-five percent have graduated from high school. Twenty-two percent have attended college. For the most part, these trainees have *learned to learn.*

Since these military trainees grew up in industrial America and have had considerable formal education in the American school system, we assumed that they were already familiar with the following:

1. Electrical cords, plugs and outlets, such as used in homes, schools, etc., as conductors of electricity.
2. Flow of electricity through circuits, controlled by switches.
3. Sound volume controls such as found in radios, phonographs, televisions, and other audio equipment.
4. Electrical motors, such as found in vacuum cleaners, washing machines, electric fans and mixers, and their functional responsibility in the supply of mechanical power.
5. Incandescent lamps, common items in homes, schools, businesses, etc., as a source of light.
6. Sound amplifying systems, such as used in all radios, televisions, phonographs, etc.

The objective of the film was to instruct the intended audiences, described in the preceding paragraphs, so that they would both feel competent to and be able to perform the following operations on the projector:

1. Preoperation check of electrical connections.
2. Threading of film through the projector.
3. Preoperation check on sound system.
4. Prethread cleaning of film path.
5. Prethread and preprojection focusing.
6. Replacement of projection and exciter lamps, and other operating spares.

In addition, it was important that, insofar as possible, the film influence the attitude of the trainees toward the projector and its care and use. These attitudes were spelled out, as follows:

1. The good projectionist uses common sense.
2. While the projector set appears to be complicated, the mastery of the equipment is not difficult if recommended procedures are observed.
3. Careful checking and cleaning of the equipment should be performed before each use.
4. The equipment is not too heavy for men to carry.
5. There is more to learn about the equipment than is shown in the film.

The film was produced for use in organized Army projectionist courses. In all such courses, ample provision is made for classroom practice on the projector set, under the supervision and guidance of the instructor.

In the instructional procedure, the training film, TF 11-1752, will be shown immediately before the students are permitted to handle the projection equipment. A second showing of the film will be scheduled at the end of the course, just prior to the period for the qualifying examinations. Another Army training film, TF 11-1574 *Technique of Good Pro-*

jection, is already being used in the course and will continue in the schedule, to show the importance of good projection in the classroom and how this is accomplished.

With such advanced knowledge of the situation of use, the instruction and practice to follow the showing of the film, and the availability of a sister film covering projection techniques, it was possible to limit the content of the film to the essentials of prepractice instruction. Furthermore, the fact that the audience was enrolled in a projectionist training course made it possible to eliminate the "establishing sequences" and to open directly on the subject. Assembly and disassembly of the equipments were omitted from the film, since these operations are taught in the practice phase, working directly with the equipment.

Considerable experience gained from associating with projectionists and teaching projectionist training courses, and considerable thinking on the objectives of the film in terms of audience performance and audience attitudes toward the Army projector set, went into the first treatment of the story outline, prior to conferences with the writer regarding scenario preparation. The nature of the audience, the assumptions on existing knowledge of the audience, the objectives of the film in terms of performance and attitudes, and the situation of film use were spelled out in advance of the scenario-planning phase.

We encountered no difficulty, no misunderstandings, no obstruction and no opposition anywhere along the line, once performance specifications were clearly set forth for all to examine.

Auditorium Specifically Designed for Technical Meetings

By D. MAX BEARD and A. M. ERICKSON

The Naval Ordnance Laboratory, White Oak, Md., is not only a research and development center for ordnance material, but it has also become a center for the dissemination of scientific information. Technical meetings and symposia of international fame have been held in the auditorium, specifically designed for such meetings, seating 550, with optimum acoustics. Included are a console for control of 21 microphones, telephone communication with the moderator, and controlled levels to sound recording facilities. The projectionist has direct contact with the speaker, the console, the thyratron-controlled overhead lights, and preset stage lighting. Complete audio-visual aids are available.

The Naval Ordnance Laboratory has the primary objective of the development of new and better ordnance for the United States Navy's Bureau of Ordnance, and is destined to become one of the outstanding research centers of the nation. It must be realized not only that it is essential to equip this research activity with the most modern and complete facilities, but also the laboratory must be equally well equipped with a staff of fully informed scientific personnel.

It was recognized late in World War II, while planning for the new laboratory at White Oak, Md., that every effort should be expended to maintain adequately trained technical personnel to make and keep this laboratory a noteworthy research center — whether at war or in peacetime. As a result of these efforts, this laboratory has, in addition, become an intellectual center for the dissemination of scientific information. It is for this phase of endeavor that its auditorium was planned and is dedicated.

The lot of the scientist speaker is not always an easy one. His subject is usually one that must be closely followed and have a minimum of interruptions. He must have full assurance that he can be heard or that his visual aids are clearly discernible to the entire audience. Of equal importance is the comfort of his audience, who must expend a considerable amount of mental effort to keep up with the subject, and certainly cannot do so if there is an accumulation of distractions such as hard seats, foul

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by D. Max Beard, Naval Ordnance Laboratory, Silver Spring, Md.

Fig. 1. The NOL auditorium showing lectern in its normal position, with microphones in place for audience participation. Questions may also be written down and handed to assistants at the aisle mikes.

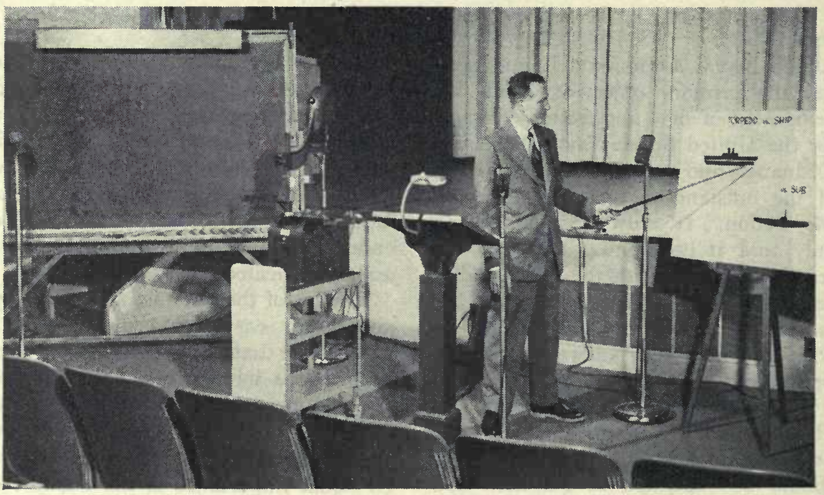

Fig. 2. Visual aids, such as opaque projection, Viewgraph, charts, blackboard, pointers, etc., are readily available to the speaker even when presenting his talk to a small group from out in front of the stage. Microphones are strategically placed to give the lecturer as much freedom as possible, while at other times lapel microphones are used. Floor outlets would be preferred to the present outlets along the front of the stage.

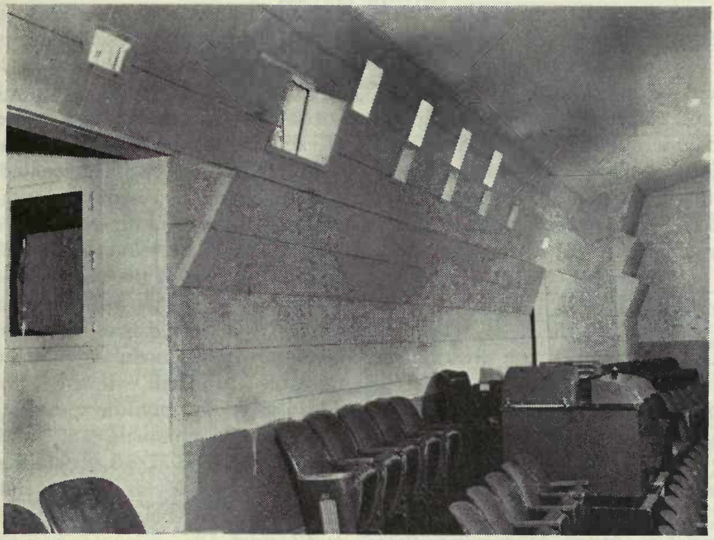

Fig. 3. Rear of the auditorium showing the location of the control console, the contour of the rear wall and the projection-room parts.

air, disturbing lights and poor auditorium acoustics. The NOL auditorium is designed to put both the speaker and his audience at ease.

The major points considered in the design of this auditorium were: (1) audience comfort; (2) intelligibility; (3) availability of visual aids; (4) controlled levels of illumination and sound; and (5) flexibility of the overall system. The facilities for these results are herein described.

Several members of this Society gave excellent advice, and were instrumental in the final design and engineering of the auditorium. Since most contacts were made through the Society, the writers would like to express their appreciation to the Society for this assistance. However, special mention is made of the work of Al Ward and John Volkmann of the Radio Corporation of America who were responsible for the acoustics and sound system engineering, and J. E. Currie of the National Theatre Supply Company who assisted in the layout of the projection sound system on the stage and in the projection booth. The Photographic Division of this laboratory is responsible for the further tailoring of the installation in its present exacting requirements and its operation.

The auditorium, seating 550, has a reverberation time of approximately 0.75 sec, which is slightly less than that of a comparable-size (200,000-cu ft) motion picture theater (see Figs. 1, 2 and 3). To achieve these desirable acoustics, and to keep within the structural limitations of the building, the interior was altered to include polycylindrical sections, sloping floors and a serrated rear wall. Absorbing material was selected and placed to give optimum acoustics, with side walls surfaced with acoustic plaster, the ceiling of standard plaster, and overstuffed theater seats. An on-the-stage lecturer with good speaking quality may be easily heard at the rear of the auditorium without the aid of sound reinforcing. These acoustic properties are not only desirable for lectures, but are ideal for recording purposes.

The stage is similar to small theater installations with several added features such as: (1) a one-ton hoist for moving equipment for demonstrations; (2) alternating- and direct-current power, signaling and microphone outlets available at various points; (3) microphones behind the projection screen, permitting the speaker to have complete freedom from the lectern; (4) removable projection screen and motion picture speaker systems; and (5) sound reinforcing speakers overhead and slightly in front of the stage in the proscenium arch.

The projection booth, shown in Fig. 4, is equipped to handle 16mm and 35mm motion pictures, and 2 in. × 2 in. standard and continental lantern slides.

The standard-size dissolving slide projector was altered to accommodate 1000-w incandescent projection lamps, with special blowers and heat-resistant glass to permit prolonged projection of negative lantern slides. This is quite important since some scientists may discuss one lantern slide for as long as ten minutes. House-light dimmer and curtain controls are located in the booth at each of the viewing ports. The stage light control is centrally located.

Slide-changer buzzer, auditorium monitor, intercommunication and telephone communication are readily accessible to most of the normal operating positions. Accurate focusing of all projectors is accomplished by means of a seven-power monocular sight that is movable to each viewing port. In addition to the monitor speakers on the two sound channels, a sound-level meter is bridged across the stage speaker bus and provides a positive indication of sound level being delivered to the auditorium.

The auditorium sound reinforcing system (Fig. 5) is designed to be controlled from a mixing console (Fig. 6)

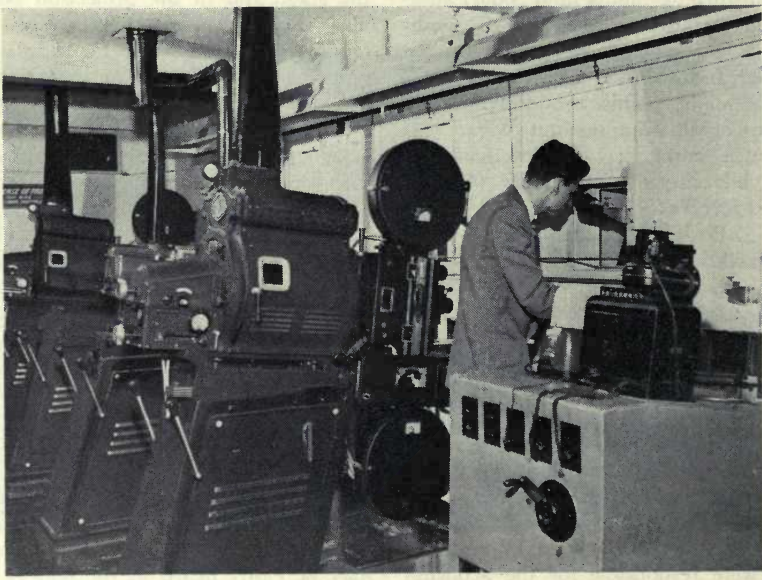

Fig. 4. The projectionist utilizes a monocular sight to get accurate focus on all projection from the booth. The dissolving slide projector controls and modified heat-dissipating system may be noted on the projector at the right of the operator.

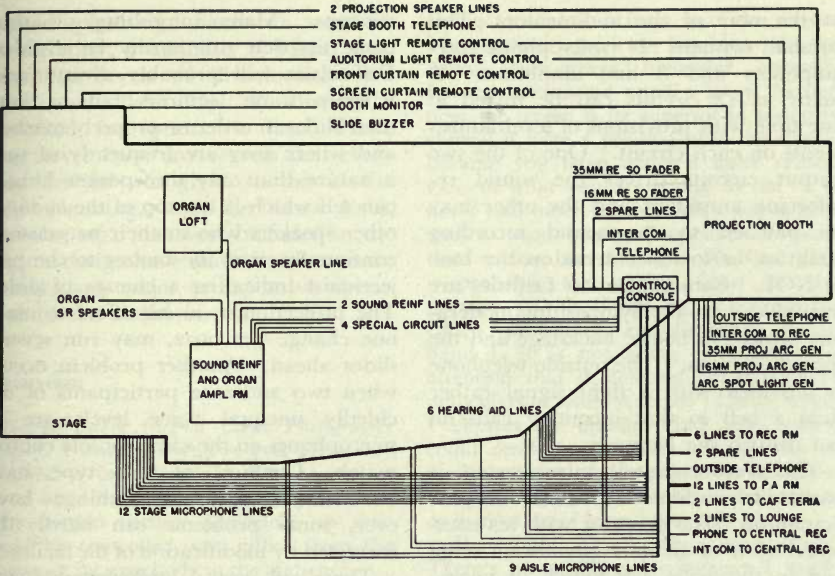

Fig. 5. Schematic of sound and control services. The entire operation for limited services may be controlled from the projection booth, utilizing preset levels at the control console.

Fig. 6. The operator of the control console not only has a clear view of any activity in the auditorium, but has complete control of all sound facilities by means of switches, attenuators for sound reinforcing and recording.

at the rear of the auditorium. This console contains 21 microphone preamplifiers and 2 line amplifiers. As many as 12 circuits can be mixed at one time with provisions of level adjustments on each circuit. One of the two output circuits drives the sound reinforcing amplifiers and the other may be patched to the sound recording facilities, or to other areas on the base at NOL. Communication facilities are available with the symposium moderator, projection booth, backstage and the recording room. The outside telephone is provided with a light signal rather than a bell so that incoming calls do not disturb the lecturers.

This control console mixer system is particularly adapted to audience participation. The operator with his command view of all microphones on stage and in the aisles can switch in microphones or interchange and maintain levels as required. The result is excellent sound reinforcing of all pertinent discussions regardless of whether they are between the lecturer and a participant from the audience, or among two or three members of the audience. This flexibility is extremely valuable where it is desirable to record every word of international symposia.

The auditorium is utilized in many different ways:

(1) For week-long symposia, nearly every facility must be made available to include audience participation, all projection services, lapel microphones, lectern, projectionist working from scripts, intercommunication with outside activities, and complete sound recording, which includes all verbal combats between members of the audience. Performances of this type have not only been completely recorded, but transcribed and eventually published in book form.

(2) Seminars.

(3) Public-speaking training courses.

(4) Junior professional training.

(5) Intra-Defense Department discussions. Many interesting situations come up that can hardly be avoided. Difficulties will probably always arise wherein some lecturers fail to have their slides in order or properly marked, and where they are frequently of such a nature that only the speaker himself can tell which is the top of the slide, or other speakers who in their nervousness continually press the buzzer to the projectionist indicating a change of slides. The projectionist, in his effort to make one change per buzz, may run several slides ahead. Another problem occurs when two audience participants of decidedly unequal voice levels are at microphones on the same console control switch. Conflicts of this type have been eliminated by repatching; however, some problems can hardly be corrected by modification of the facilities.

There are several improvements that are highly desirable in an auditorium designed for this type of operation. Most noticeable among these are the requirements for panels for the use of charts, etc., that may be pushed off stage when no longer required; more complete facilities in front of the stage for small groups; a system of lights on lectern (in view of the speaker only) controlled by the moderator, to warn the speaker he is lecturing beyond his allotted time; an improved system of microphones for audience participation; screen set flush with the rear of the stage; acoustic baffles on the air-conditioning ducts; a stereophonic sound and projection system; acoustic treatment in the booth; and possible use of variable-focal-length lenses for 2 in. $\times$ 2 in. slide projection. The magnetic sound track on 16mm film will be a boon to the functions of this auditorium.

The auditorium at NOL, although originally planned about seven years ago, has been kept up to date in most respects and has proven most satisfactory in nearly every respect for the type of performance required of it. Of the five major points considered in the

original planning: audience comfort, intelligibility, availability of visual aids, controlled levels of illumination and sound, and flexibility, the one most overtaxed has been the last. There have never been any regrets that every consideration was given to this in the early planning, and the extra lines, conduits, etc., that were included in the original design have made it unnecessary to make any major or expensive alterations to the auditorium.

Discussion

George Lewin (*Signal Corps Photographic Center*): I wonder if you've ever given any thought to providing a remote-control of focus on either your slide projectors or your motion picture projectors, so they could be controlled, say, either from the lectern or by somebody in the audience.

Max Beard: We have never tried that. Does it work pretty well?

Mr. Lewin: Well we use it to some extent in running dailies, because there's always a question as to whether the projectionist has the same idea about focus as the audience.

Mr. Beard: I wonder if the speaker close to a screen could determine the focus as accurately as the man from the booth with the telescope;

Mr. Lewin: Well, probably not the person near the screen, but somebody in the audience, that is somebody assigned, of course, by the speaker could take care of that.

Mr. Beard: It's of interest to point out that very often when you're running film, the film goes in and out of focus at times for reasons beyond the control of the projectionist (he's not always watching it that closely).

Chauncey L. Greene (*RKO Orpheum Theater, Minneapolis*): I've used the seven-power binocular for checking focus as well as trying to control it from near the screen. My personal experience has been that the Navy seven-power binocular critically focused beforehand upon a target located near the screen is far superior to trying to control it from a position near the screen, because you have really a more critical view of what you are trying to do. I've never had much success with a monocular, and a poor quality binocular is worse than useless, but that 7 × 50 Navy glass is probably the world's finest for this purpose. True, if you try to operate the entire projection establishment single-handed, it is not going to receive the attention that it deserves either through binoculars or without them. Lastly, might I express an opinion that this Society could render no greater service than to mail a reprint of this paper to the Visual Education Department of every college or institution of learning in this country.

Mr. Beard: Thank you, Mr. Green. There's an additional comment I might make. The biggest problem we have, when focusing, is the shifting from $3\frac{1}{4}$ in. × $3\frac{1}{4}$ in. to a $3\frac{1}{4}$ in. × 4 in. lantern slides. The projector we have has different positions for these two types of slides, which means that every time you project the continental slide ($3\frac{1}{4}$ in. × $3\frac{1}{4}$ in.) you have to refocus the projector. This is a big problem with us, since we frequently get a mixture of the continental and standard slides.

Chester Beachell (*National Film Board of Canada*): Have you any facilities in this auditorium for providing different screens, such as perforated matte, a beaded screen, or a silver screen for a Polaroid stereo projection?

Mr. Beard: We use the perforated screen for all projection. We have not tried the Polaroid system; however, we are quite anxious to do so some day.

Mr. Beachell: It has been my experience that a matte screen won't work on Polaroid stereo at all. It scrambles the light polarity.

Safety Requirements in Projection Rooms and Television Studios

By SAMUEL R. TODD

Nitrate film has imposed special requirements on projection-room design for many years. The advent of 35mm safety film may change some of these, and this possibility is discussed. The increasing use of films, both nitrate and safety types, in television studio operations calls for similar precautions, and the presence of considerable electronic equipment adds to the normal hazards. These hazards and certain others peculiar to live program presentations are discussed. Safety problems involved in the installation and operation of high-voltage television equipment in theaters are outlined.

PROJECTION ROOMS IN MOTION PICTURE THEATERS

Since the first "Nickelodeon" opened its doors to the public for presentation of motion pictures the greatest safety hazard, as is well known, has been the fire and panic danger inherent in the ever-present possibility of accidental ignition of the thousands of feet of cellulose nitrate film located in the projection room. This continuing hazardous condition over the years has been changed recently, to a considerable degree, due to the gradual replacement of nitrate film by the so-called "safety" cellulose acetate film. However, as long as 35mm film remains standard for the projection of motion pictures in theaters, most safety authorities, many theater owners, and those theater designers who are intimately conversant with the numerous details involved in the proper design and construction of modern projection rooms for maximum safety and best operating features, feel that any changes in the specifications now considered as standard are both unwarranted and undesirable. If we assume, and it is a fair supposition, that a fireproof type of construction for theaters will continue to be demanded by local governmental authorities, it seems hardly possible that nonfireproof type of construction for projection rooms would be advocated.

Let us consider, item by item, some of the real reasons for the present type of enclosure for the projection, sound and accessory equipment in the modern theater projection room. To isolate from the auditorium unavoidable noises, such as those due to the operation of equipment and due to conversation necessary from time to time, a sub-

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stantial enclosure is certainly needed. The physical strength alone required to safely support the weight of the necessary equipment, and to allow for the additional weight of four or more persons who may be in the room at one time, calls for the specification of a heavy reinforced concrete floor constructed according to the recommendations of a qualified structural engineer. Also, and for similar reasons, the four walls of the room should be designed to assure structural security and adequate fire protection as well as the necessary physical strength required to support electrical raceways and heavy equipment items which may be mounted on these walls. From long experience in projection-room design, it seems advisable to call for ceilings not less than 9 ft above the projection-room floor level, and of structurally strong and fireproof construction. Costly films, sound and projection systems need protection from theft and from fire hazards elsewhere in the theater as well as vice versa. Solid, fireproof enclosures, with approved fireproof doors equipped with trustworthy locks, are thus well justified whether or not the films used introduce any special fire hazards.

In the event a fire does occur in the projection room, it is instantly and imperatively necessary to completely isolate the room from the auditorium in order to prevent possible audience panic. Panics kill far more people than actual fires do. Projection and observation port openings must be equipped with gravity-operated, automatically controlled, approved steel fire shutters actuated by a master control cord and by 160° fusible links, located immediately above and within 6 in. of the upper magazine of each projection machine. In the event of a projection-room fire, it is necessary to exhaust promptly all smoke and odors to the outside air. This may be accomplished by means of an adequate, forced-draft ventilating system; this system may also serve to exhaust normally the gases and carbon ash from carbon-arc lamp enclosures. A natural gravity vent, with adequate cross-sectional area extending through the projection room ceiling directly to the outside air, should also be provided as protection in case of failure of the electricity supply service.

Consideration should be given to the dimensions of the projection room in order to provide normal operating safety factors for the projectionist. The room should be not less than 12 ft between front and rear walls, in order to have sufficient working and free walking space around all equipment. The rewind table should be located at the rear wall equidistant from the two projectors. The space between projectors should be sixty in. at the lens centers and there should be a clear space from the lens centers of 48 in. both to the right of the righthand projector and to the left of the lefthand projector. A modern design for the rewind table includes space beneath the table top for locating approved-type film containers, supported several inches above the floor. In order to deliver on the screen the high-quality performance expected from the projectionist, he must at all times, while on duty, be reasonably calm and alert both mentally and physically. These considerations, as well as those of common decency, call for providing adequate modern toilet facilities and a lavatory with both hot and cold running water in well-designed theater projection rooms.

This brief review and discussion of present safety requirements in theater projection-room construction is intended to justify the conclusion that practically all of the requirements are in order regardless of the type of film used. They obviously must not be relaxed in any degree so long as there is a possibility that even small quantities of cellulose nitrate film may reach the theater, and this possibility may be with us for years to come. Entirely

apart from this, however, it has been shown that they lead to improved program presentation and better general safety conditions for both the public and the theater personnel. This is important; twenty years of good engineering design and proven operational practices have created public confidence in theater safety. This could be destroyed by a single instance where loss of life was rightfully or wrongfully attributed to a relaxation in the presently accepted standards. Furthermore, it should be kept constantly in mind that there is no moral defense for anyone who may be responsible for deliberate laxity in the construction and operation of theater projection rooms if a fire does occur and the sordid picture of a disastrous panic is the tragic result.

TELEVISION INSTALLATIONS

Projection Rooms

The equipment necessary in television station projection rooms creates possible hazards of the same type inherent in the projection rooms of motion picture theaters. With the present use of 35mm film and projectors equipped with the Synchro-Lite, instead of the conventional carbon-arc lamps, hazards affecting the safety of the operating personnel are definitely and continuously present. For example, this gas-discharge gap lamp employs potentials up to 5000 v across its terminals. The standard motion picture projection equipment, as observed in television station projection rooms, consists of two 16mm projectors and two 35mm projectors, each equipped with the Synchro-Lite as the light source. As long as 35mm film continues to be used for programming purposes, the hazard inherent in the possible use of nitrate base film will require the acceptance of safety regulations as heretofore found necessary in the projection rooms of motion picture theaters.

The panic that may be created by the sudden and violent combustion due to the ignition of perhaps a thousand or more feet of nitrate film, or the uncomfortable situation incident to one of the operating personnel lying prone from the effects of an electric shock, are possible situations requiring very special consideration from those individuals charged with the responsibility for formulating safety rules and regulations for television station projection rooms.

The safety requirements for projection rooms in television stations should include as a minimum: (a) standard fireproof construction of the projection room; (b) the proper floor dimensions to provide good operating conditions; (c) approved storage facilities for the film; (d) an approved rewinding device for 35mm film; (e) the installation of approved, self-closing, automatically controlled fire shutters for the port holes; (f) the proper projection-room ventilation, including both gravity and forced-draft methods; and (g) the provision of adequate means for instant exit for the operating personnel through openings equipped with fireproof self-closing doors opening outward. As in the case of theater projection rooms, nearly all of these requirements are fully justified on a simple common-sense basis without any consideration of the special hazards introduced by the possible use of cellulose nitrate film. A typical television projection room incorporating the design features which have been mentioned would be self-contained, having the moving picture machines project the light through a wall directly into the camera chain located in the adjoining room. Figure 1 shows in detail some of the safety features incorporated in a typical well-designed television studio projection room.

Studios

With the increasing use of a great variety of household appliances in the production of television programs, haz-

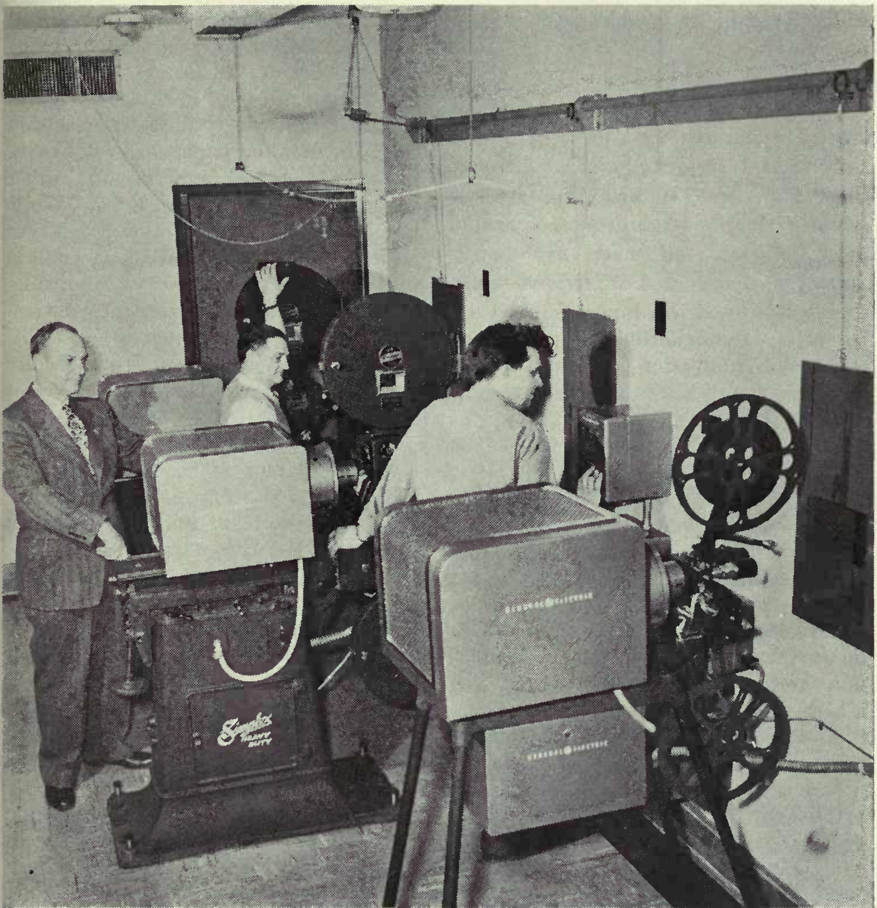


Fig. 1. A typical well-designed television studio projection room showing in some detail some of the safety features.

ards are being introduced which require continuing alertness on the part of the producing and operating personnel. For example, in the demonstration of open-jet gas ranges the possibility of conflagration in the studio is always present. Perhaps to a lesser degree this also applies to the use and demonstration of electric ranges and other electrical appliances with exposed heating elements.

In the larger studios, with arrangements for seating studio audiences of 50 to 100 persons, the producing and operating personnel must ever be alert to unforeseen accidents that may cause a panic. Figure 2 shows a typical, large studio with the possibility of having large numbers of people confined within its walls and hence subject to all the usual and unusual panic hazards. In addition to the possible hazards just mentioned, special attention should be given to the safe installation of heavy lighting equipment, whether such equipment is directly suspended from the

ceiling or mounted on balconies, and to adequate supports for heavy lighting units at the floor level. These precautions should also apply to special rigging apparatus used to support and shift special scenic effects, and to all stage properties. In these larger studios, where relatively large groups of people are admitted, adequate exits with approved illuminated directional signs should be provided. Figure 3 shows the extent of the special lighting equipment and other production apparatus which may be encountered in a typical modern studio.

Theater Television Using Direct Projection

The installation of theater television equipment has introduced problems not heretofore present in providing motion picture screen presentations. Essentially, the equipment purchased by the theater owner for such an installation consists of three major items: (a) a high-voltage supply unit weighing 800 lb and providing 20,000-v and 80,000-v output circuits; (b) video control amplifier units mounted on conventional racks and weighing 1200 lb; and (c) a picture projection unit which with its mounting trunnion weighs 400 lb. This by no means small extra weight of over a ton introduces a definite safety hazard to the building structure in many instances. Structural loading factors need to be thoroughly checked before the installation of such massive equipment.

Because of the high potentials produced by the voltage supply unit it is essential that it be located in a separate fireproof room with the entrance door closed and locked at all times. It is preferable to locate the unit as near as possible to the optical barrel which encloses the picture projection tube in order to reduce the required length of the special 80,000-v cable which connects to the second anode of the picture tube.

The video amplifier unit is mounted on two racks occupying a floor space 40 in. wide and 18 in. deep extending to a height of 64 in. in the theater projection room. It contains a television receiver, monitor panel, control panels, low-voltage power supplies and other miscellaneous operating units. While required projection-room space is not large, the room dimensions should provide enough to avoid overcrowding and consequent reduction in normal operating safety factors.

The proper location of the picture projection tube and optical barrel is very important from the viewpoint of safety to the public and it is also a very important factor in securing best projection quality. The nominal "throw" from the projection unit to the screen is 60 to 65 ft. *In a typical installation*, a heavy steel platform was installed for mounting the optical unit. This platform was mounted on the front face of the first balcony rail in such a manner as to preclude any possibility of unauthorized persons having access to or coming in contact with the projection tube or any of its high-voltage terminals. In this position, the tube and optical barrel projected a 15×20 ft picture on the screen at a "throw" of 62 ft. In theaters having no balconies the projection unit must be supported from the floor or ceiling and, as in the case of balcony support, the mounting structure must be adequately designed to eliminate any possibility of either electrical or mechanical hazards to theater personnel or audience. The unit should be enclosed in such a manner that any corona or arcing due to dampness is not visible.

Presently available direct projection television equipment is very well designed from the viewpoint of having adequate safety disconnect switches at all points where dangerous potentials may be encountered. Switches are provided, for example, at the access door to the high-voltage power supply room,

Fig. 2. A typical large studio showing the possiblity of accommodating large numbers of people.

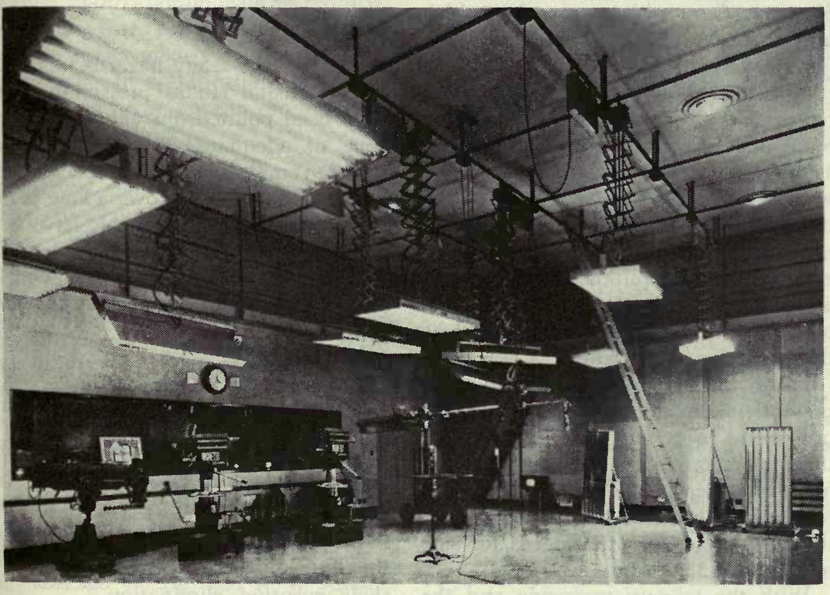


Fig. 3. A typical modern studio showing the extent of the special lighting equipment and other production apparatus which may be encountered.

on the enclosure for the picture projection tube and on various components of the amplifier and control equipment. It is extremely important that all of these safety circuits be intact at all times. Unauthorized modifications are the height of foolishness where potentials dangerous to life are concerned.

FILM METHOD FOR THEATER TELEVISION PROJECTION

This method, the so-called storage-type system, for television theater projection uses a 35mm motion picture camera to photograph a negative image on a television receiver to produce a direct-positive print. The exposed film is transported continuously to equipment for rapid development and drying. From this equipment it is transported to the projector for immediate projection on the theater screen. The elapsed time from the television camera pickup at the scene of action to the time of projection of the completed positive print on the theater screen is 61 sec.

This method requires a properly ventilated room of fireproof construction for the television receiver, the 35mm picture camera with a magazine which may contain 12,000 ft of unexposed film, and for the developing and drying equipment. This room obviously must be adjacent to the theater projection room and provision must be made for feeding the completed positive print to the upper fire valve rollers of the theater projector, from which the upper magazine has been removed. This arrangement of equipment will provide a continuous projection of motion pictures on the theater screen for more than two hours' duration.

From the viewpoint of safety, the present method used for feeding the processed print to and across the theater projection room to the projector head on a series of open pulleys could hardly be considered as complying with the most elementary standards for safe handling of 35mm film.

With the take-up magazine and the take-up device on the projector designed for only approximately 2000 ft of film, it is obvious that cutting of the film at the end of each 2000 ft will be required. The running end of the film must quickly be attached to the hub of an empty reel and the excess film on the projection-room floor must be spun onto the hub, after which the reel must be placed into position on the take-up spindle of the lower magazine for taking up the succeeding 2000 ft of film. This procedure must be repeated five times during the continuous projection of 12,000 ft of film. Such a procedure does not appear to follow any of the long-standing practices for the safe handling of motion picture film.

Conclusions

Some of the safety hazards in theater and television studio projection rooms have been pointed out and the importance of adequate corrective measures has been emphasized. The special safety precautions developed over a long period for theater projection rooms have been shown to be sensible and desirable without regard to the ignition characteristics of the film used, and the same considerations are shown to be applicable also to television studio projection rooms. Special hazards in television studios have been outlined. Theater television equipment, which presents safety hazards of new types, has been discussed and attention has been called to some of these in the hope that full knowledge of them will aid in their eventual elimination.

Military-Type Lenses for 35mm Motion Picture Cameras

By PAUL C. FOOTE and R. E. MIESSE

A new series of lenses for 35mm motion picture cameras has been designed as the first to primarily meet the many detailed requirements of military use. These are designated by the name Miltar, and represent the achievement of new goals. It has been a joint development by two companies who pooled resources and experience to provide a series in a minimum of time and cost with high performance. Many mechanical features have been combined with top optical performance to provide dependable operation over a wide range of conditions.

1. General Description

The Miltar series of lenses was planned to incorporate features required for military use, but not generally provided in lenses made for commercial or studio use. In specifications for either lenses or cameras appear requirements for vibration, humidity and temperature range tests more stringent than any commercial needs, which were considered in all details of the design of these lenses. Wherever possible, the recommendations of MIL-STD-150 were followed. In the specification list of lens types, these are: "Type V, for 35mm motion picture cameras."

The series is available in black for general use, as shown in Fig. 1. There is also a series in gray for the A-6 Camera, a portable 35mm motion picture camera for the Government services.

The equivalent focal lengths of the lenses in the series are based on a modified geometric progression of approximately $\sqrt{2}$, or 1.4× intervals, which give an area change of 2 from one lens to the next (Fig. 2). These are:

1-in., 25mm	4-in., 100mm
1.4-in., 35mm	6-in., 152mm
2-in., 50mm	10-in., 254mm
3-in., 75mm	

The 3-in. and 6-in. depart slightly from the exact values in the series because of the previous use of these focal lengths, and the 10-in. was included for the same reason. The first production included all but the 1.4-in. and 3-in., but these are now available.

The focal length of all lenses has been coded by the use of dots just ahead of the word "feet" on the focusing jacket in order that matched pairs, for stereo or other uses, could be picked from production lots without needing further

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by Paul C. Foote, Bell & Howell Co., 7100 McCormick Rd., Chicago 45, Ill., and R. E. Miesse, General Scientific Corp., 5151 W. 65 St., Chicago, Ill.

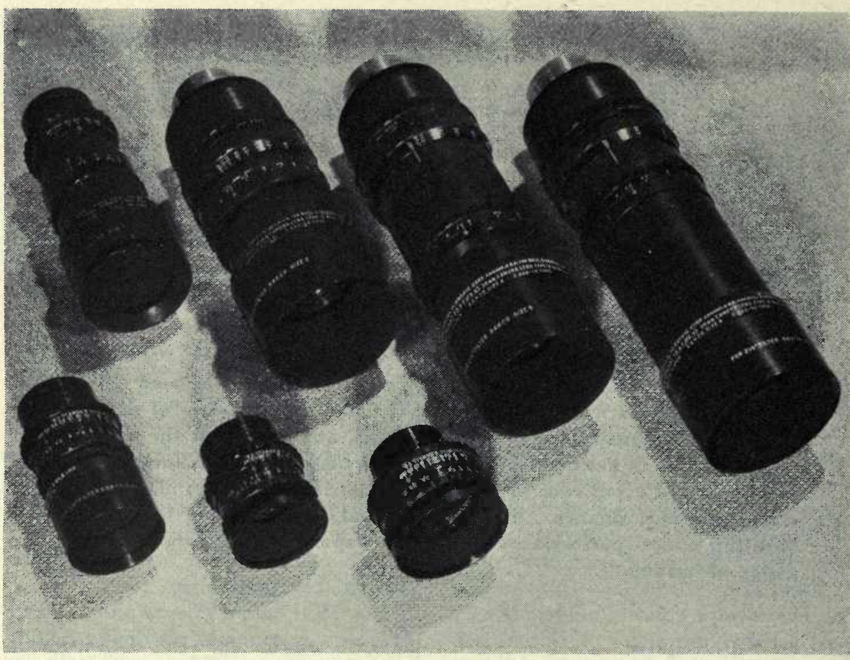


Fig. 1. **Miltar Series in black for general use.**

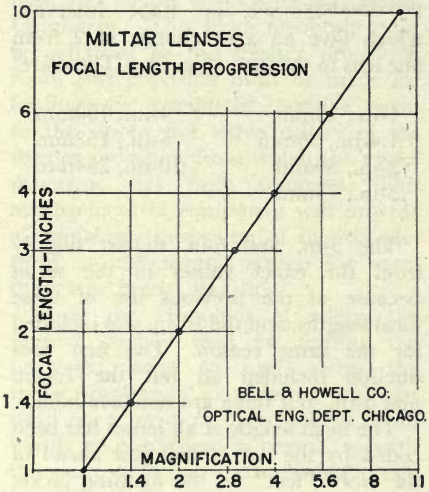


Fig. 2. Graph of effective focal length and magnification steps.

measurements. It keeps high focusing scale accuracy without individual calibration. Focal lengths are segregated into three groups, which are

plus 2% to plus 1%, three dots,
plus 1% to minus 1%, one dot, and
minus 1% to minus 2%, two dots,

and assembled into the focusing jackets that have been engraved, particularly for each group, and coded in accordance with the above ranges. The majority of the lenses fall into the nominal group: plus 1% to minus 1%, one dot.

These lenses are mounted in the military standard mount (Fig. 3) also identified as the Bell & Howell Eyemo mount, but they will also be available unmounted, or mounted in studio-type focusing jackets for the Bell & Howell Design 2709, the Mitchell, Wall or other cameras.

2. Optical Characteristics

In mapping out this Miltar series, some limitations were imposed on diameters to permit mounting lenses on existing camera turrets. The type of lens was then chosen to provide maximum performance. The 1-in. through 4-in. are 6-element construction of the Speed Panchro or Biotar form, with apertures of $f/2$, or T2.2.

The size restrictions limited the 6-in. to $f/3.5$, or T3.7, permitting the use of a well corrected triplet. The 10-in. is limited to $f/4.5$, or T4.9, and is a 4-element telephoto of standard form. In each case a special effort was made to use readily available domestic glass.

This glass, however, is held to closer than normal commercial index and dispersion tolerances.

The performance of all focal lengths is substantially increased over lenses previously supplied and is comparable to the best studio lenses. The aberrations have been corrected to give a crisp, high contrast image over the full frame.

The curves showing the aberration corrections are given in Figs. 4, 5, 6, 7, and 8. Part of the information is from the design data, part from actual measurements of production lenses.

No attempt is made here to quote resolution values, as the performance requirements of these lenses are based on results in specific cameras. Tests on spectroscopic plates do not give complete information, and tend to give a false appraisal of the practical values because of contrast differences.

Vignetting has been reduced on all focal lengths. This has required especially careful balancing of the oblique aberrations to obtain the improved contrast and resolution in the outer portions of the frame.

All air–glass surfaces are coated. Cemented elements will withstand the full temperature range and thermal shock requirements of the specifications.

3. Mechanical Characteristics

In the styling and general design, care was taken to give the lenses a matched series appearance. The diameters and physical lengths are in steps to correspond with the focal lengths and apertures. Special attention has been given the mounts and glass to obtain rugged construction for meeting thermal shock, temperature range, humidity, vibration and mechanical shock tests.

In designing this series to meet the drastic vibration requirements, every part is locked into its respective assembly with special antivibration sealing compounds and deep-set pilot screws, which again are locked into place so securely that they can only be removed by drilling.

The lenses are completely operable over the temperature range of −65 F to +160 F. All tolerances have been computed to offset the size changes for expansion and contraction through the temperature ranges.

A special noncorrosive lubricant is used which is not affected by these changes. This lubricant has a vapor pressure so low at 160° that no deposit on the glass is detectable after sustained operation at that temperature.

The diaphragm blades are lubricated with an unusual type of material, guaranteeing perfect operation over the full temperature range, with a long operating life. It has the properties of being anti-icing and noncongealing, at extremely low temperatures. Globules of condensed moisture will not freeze to the leaves, and the lubricant itself will not allow any of the leaves to bind together.

All metal parts, internal and external, are finished for high corrosion resistance. All aluminum parts are black anodized. Antireflection scoring and a durable optical black are used on all surfaces where required, internally and externally. A high-quality baked synthetic enamel is bonded to exterior

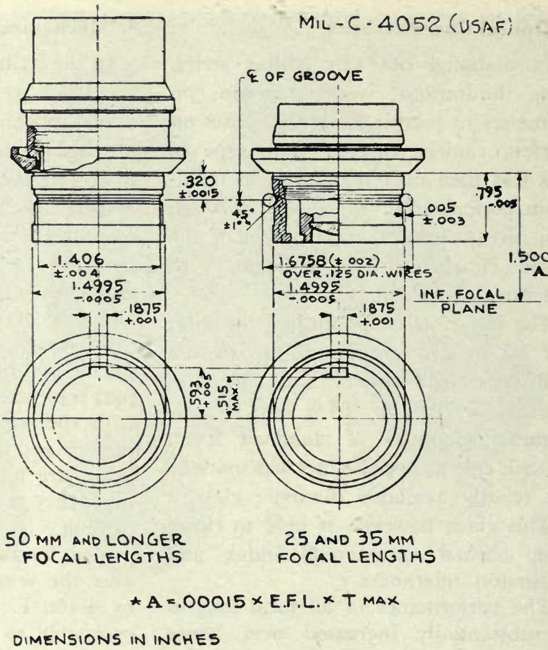


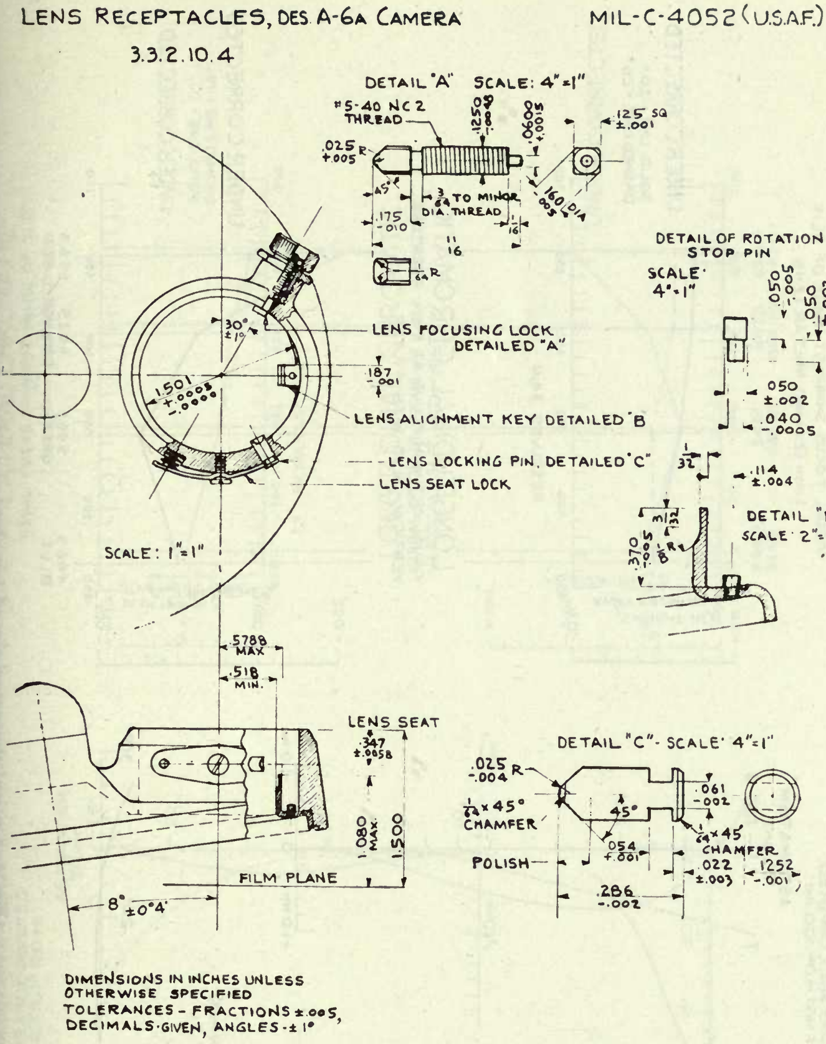
Fig. 3. Lens and camera mounting dimensions from MIL Specification.

parts, resulting in a finishing system that is extremely durable.

At present, the series is available in two external enamel finishes: gray, to match a camera on which they are used; and black, for general service use.

All control rings are adequately separated and are made as large as diameter clearances permit, with broad spaced knurls that facilitate easy manipulation, even though the operator may be wearing gloves. Focusing and iris scales are marked in easily read characters, especially designed (for all Bell & Howell lenses, not limited to this series) to prevent confusion of such characters as 3, 6 and 8, etc. The markings include full identification of the lens, its type, focal length in both inches and millimeters, filter size, sunshade thread, etc. The iris and focusing scales are designed to be read from the camera end. The lens name and filter information is designed to be read from the front of the lens.

Special provision has been made to mount standard sized filters between sunshade and lens in a convenient recess divided between both, so when the sunshade is screwed in, the filter is trapped, and protected by the sunshade (Fig. 9). The filter can be easily inserted regardless of the position of the camera. If the lens is pointed down or held on the level, the filter can be dropped into the recess on the sunshade, and the sunshade screwed into the lens. If the lens is pointed up, the filter can be dropped into the recess on the lens mount, then trapped when the sunshade is screwed into place. The filter sizes are recognized industry standards (Table I). The lens mounts have been designed to use as few sizes as possible. Four are required for this entire series: 1 using size 5, 2 using size 6, 1 using



size 7, 3 using size 8. Thread sizes and mount diameters have been kept to military and ASA standards. The sunshades have also been standardized to these specifications and marked with the filter size they retain.

Click stops are provided on the iris scales to prevent accidental movement and provide easily identified positioning. Lenses are available in either *f*/stops or individually transmission-calibrated

Table I. Filters.

Size No.	Nominal Size, in.	Max. O.D. in.	Max. O.D. mm	Max. Thickness in.	Max. Thickness mm
5	1	1.198	30.43	0.175	4.45
6	$1\frac{1}{2}$	1.634	41.5	0.195	4.95
7	2	2.006	50.95	0.219	5.55
8	$2\frac{1}{2}$	2.506	63.65	0.226	5.75

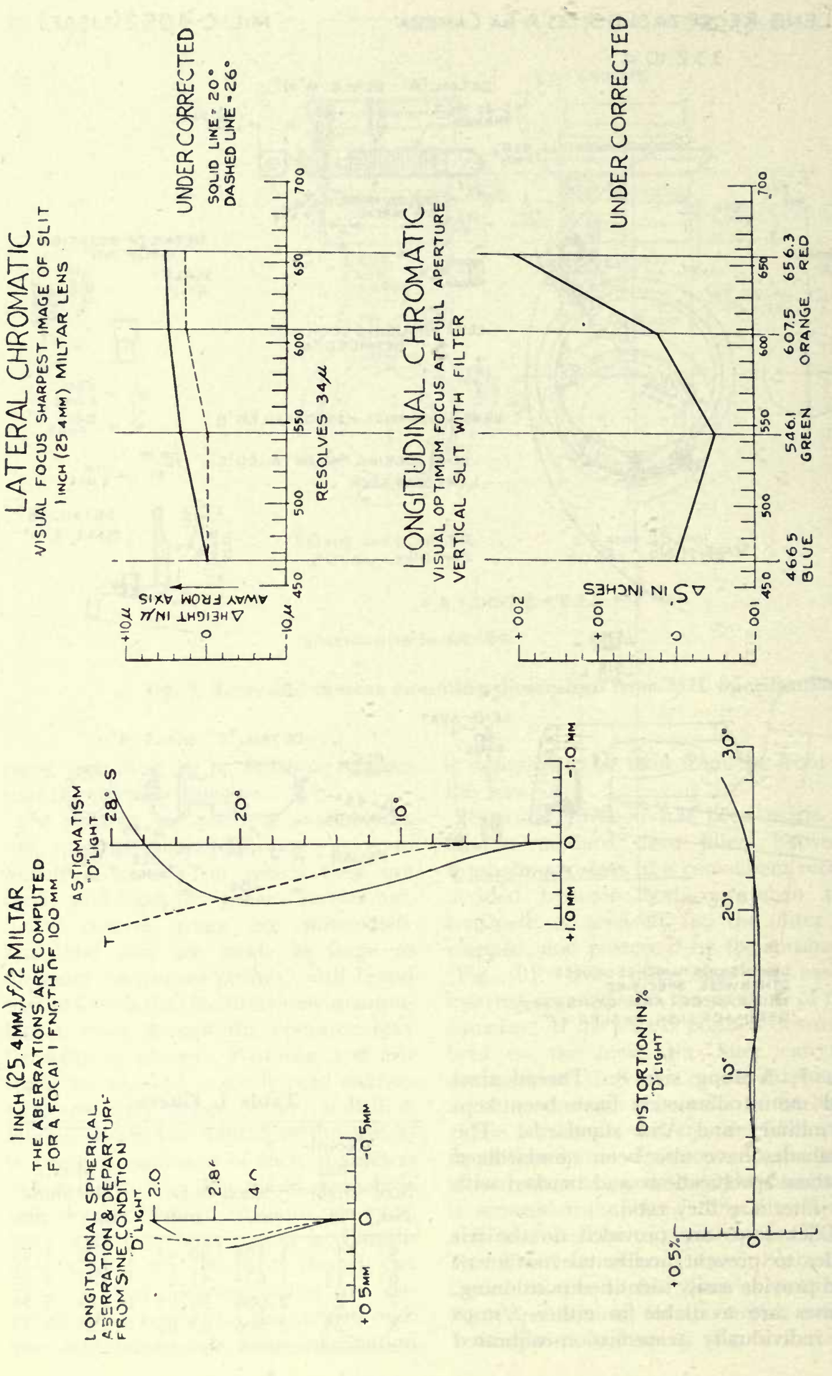


Fig. 4. Optical characteristics of 1-in. lens.

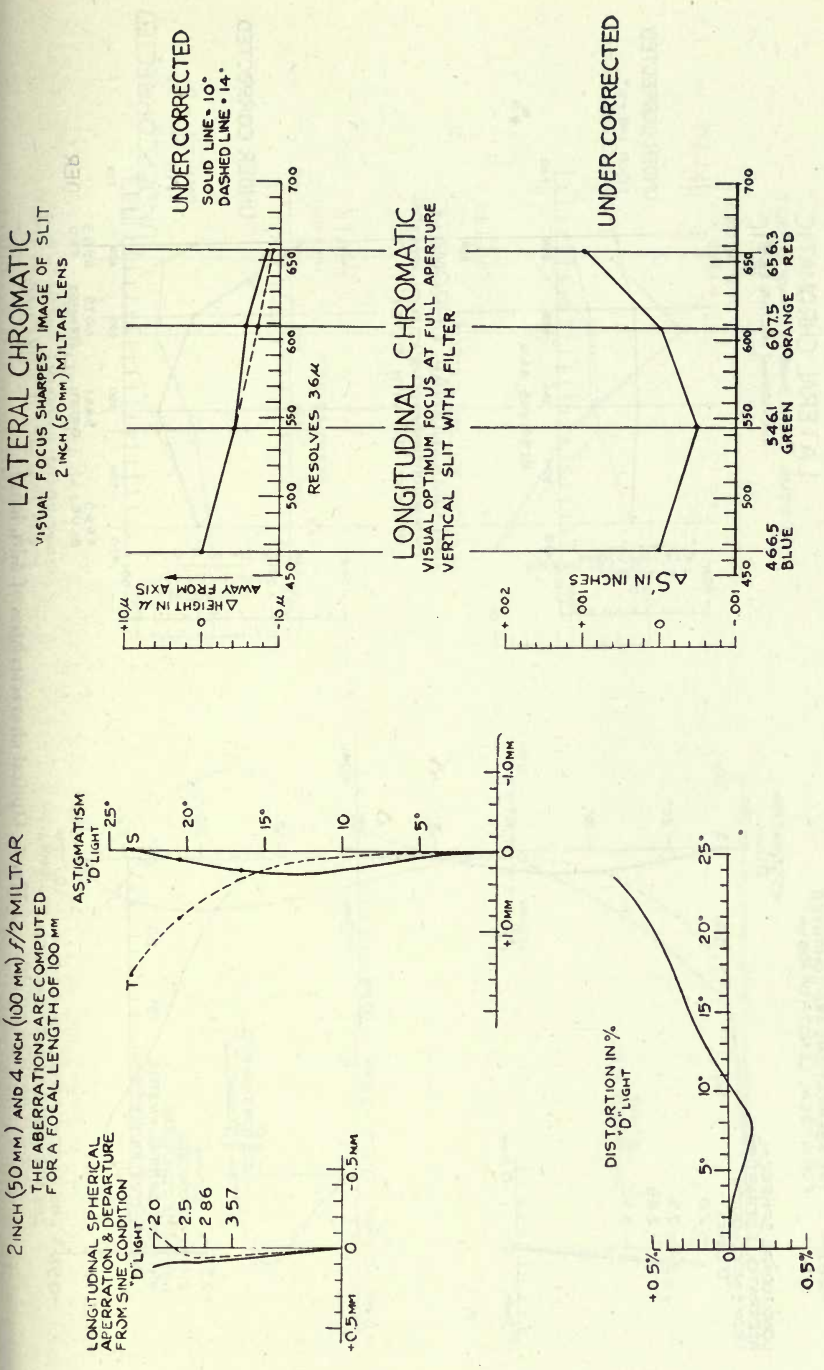


Fig. 5. Optical characteristics of 2-in. lens.

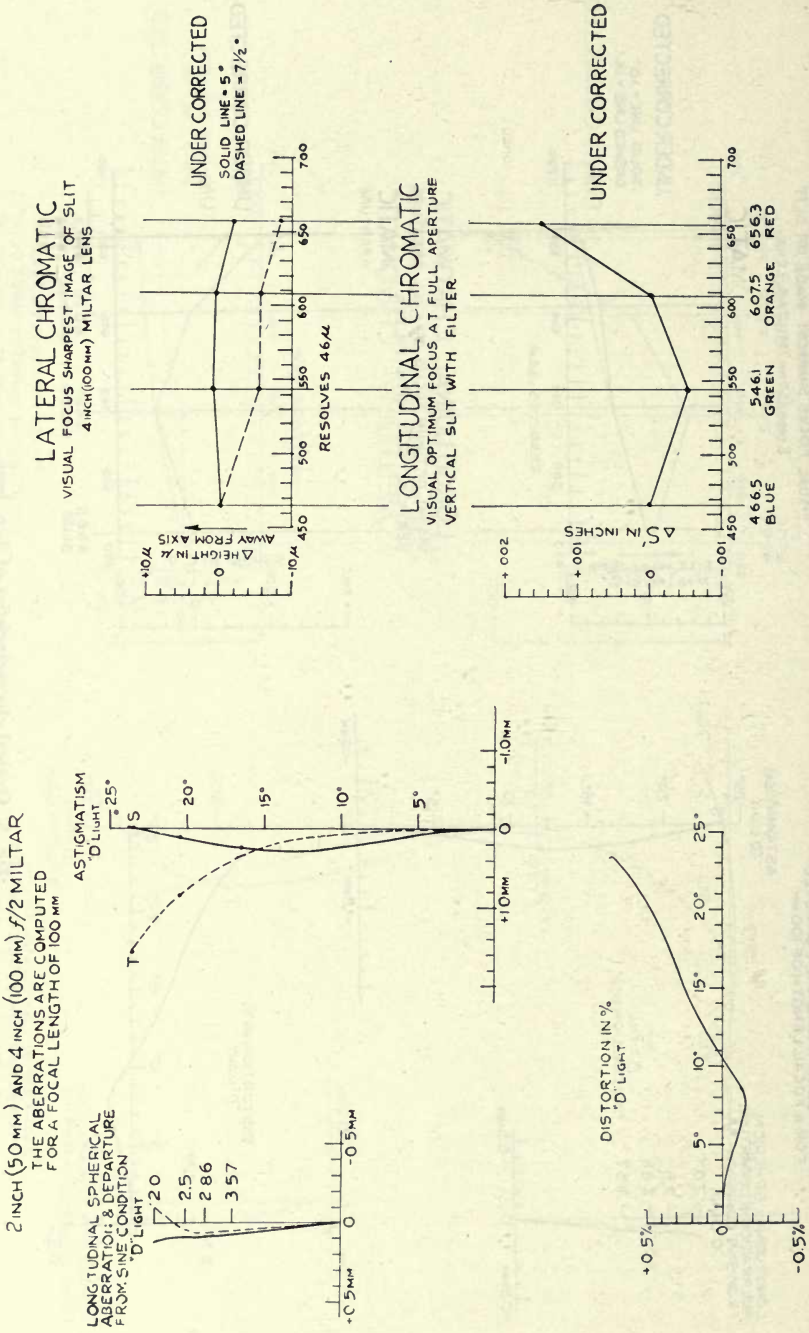


Fig. 6. Optical characteristics of 4-in. lens.

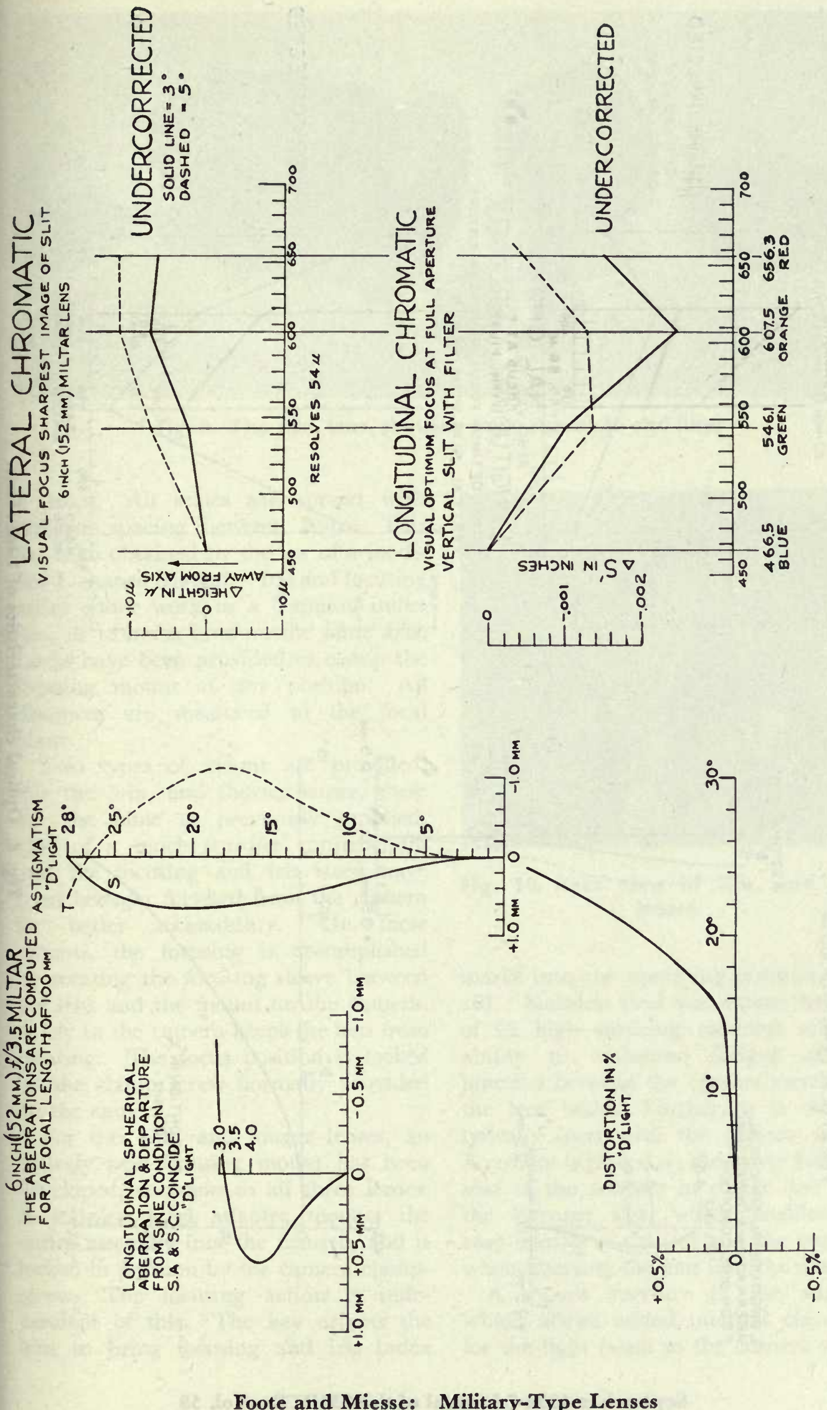


Fig. 7. Optical characteristics of 6-in. lens.

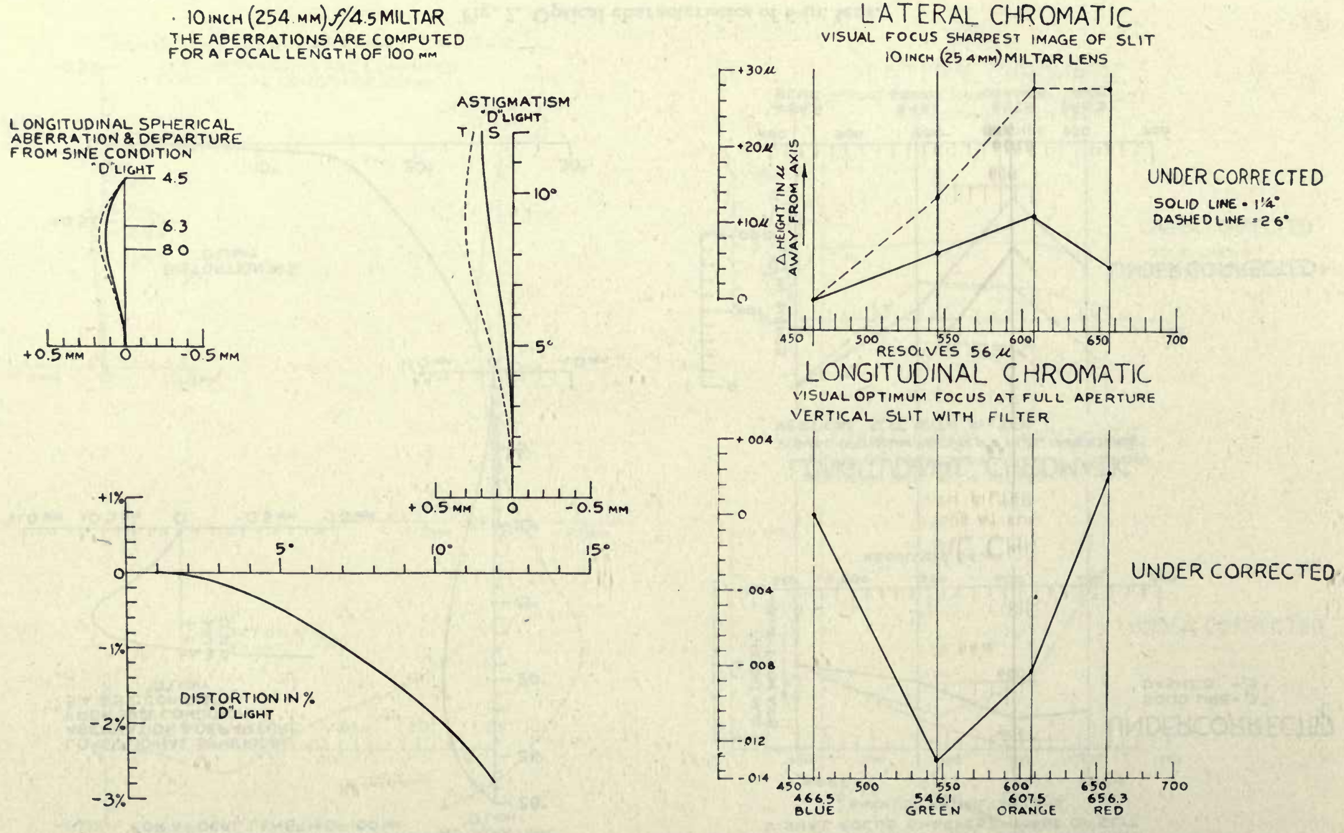


Fig. 8. Optical characteristics of 10-in. lens.

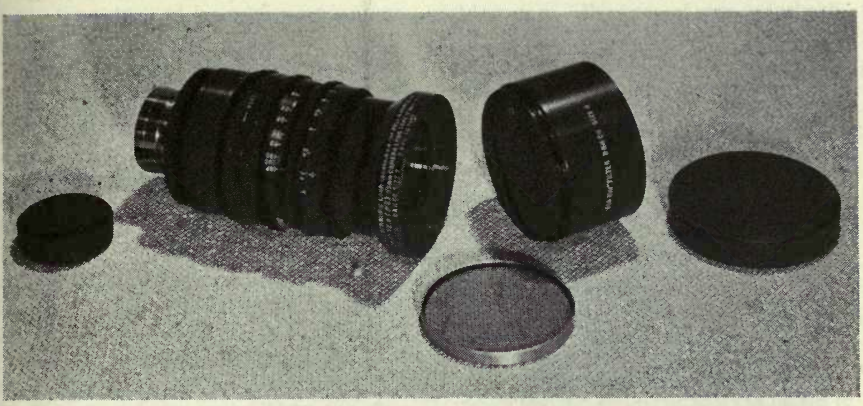


Fig. 9. The 4-in. lens, showing caps, sunshade and filter.

T stops. All scales are spread with uniform spacing between stops. This has been obtained by the use of a modified L-shaped iris leaf. Iris and focusing scales either work to a common index line, or to index lines on the same axis. Locks have been provided to clamp the focusing mount at any position. All distances are measured to the focal plane.

Two types of mount are provided. For the 3-in. and shorter lenses, these are the same as previously supplied, only of a much sturdier construction, and the focusing and iris rings have been brought forward from the camera for better accessability. On these mounts, the focusing is accomplished by rotating the focusing sleeve between the lens and the mount on the camera. A key in the camera keeps the lens from rotating. The focus position is locked by the clamp screw normally provided on the camera.

For the 4-in. and longer lenses, an entirely new focusing mount has been developed, common to all three lenses. A stainless steel adapter mounts the entire assembly into the camera, and is locked in position by the camera clamp-screw. The focusing action is independent of this. The key orients the lens to bring focusing and iris index marks into the operating position (Fig. 10). Stainless steel was chosen because of its high shearing modulus and its ability to withstand fatigue at the junction between the camera turret and the lens body. Further, it is electrolytically inert with the camera turret. A red dot is placed on the flange focusing seat of the adapter in direct line with the bayonet slot, which enables the easy mating of the slot and the bayonet when inserting the lens into the camera.

Fig. 10. Rear view of 2-in. and 4-in. lenses.

A square aperture in the adapter which allows added internal clearance for the light beam to the corners of the

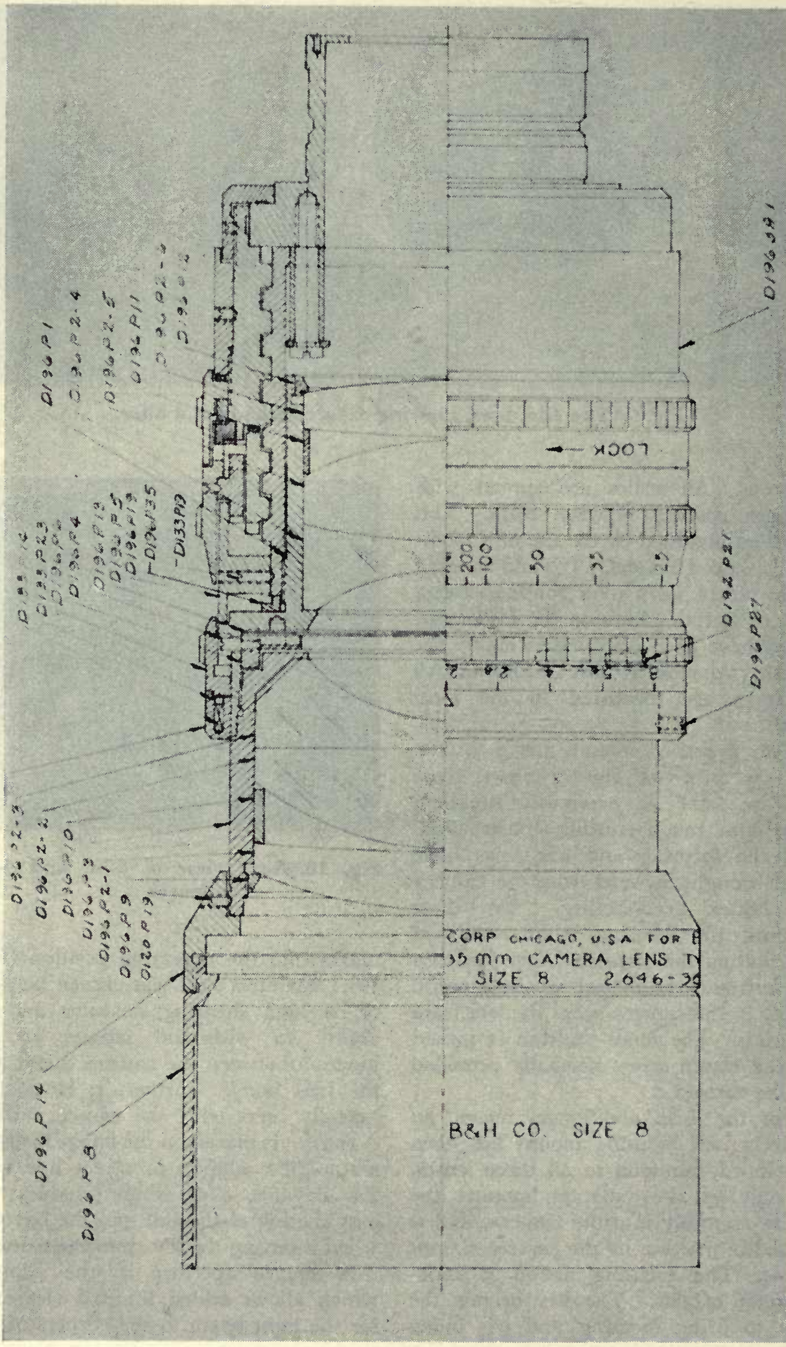


Fig. 11. Cross section of 4-in. lens.

frame is positioned by taking advantage of the slot.

The focusing jacket deserves special comment. Because of the weight of the lenses, a sturdy mount is required (Fig. 11). The focusing threads are nominally square, but the sides have a few degrees taper for ease of manufacturing, and to provide a good fit. They have been perfection-lapped with special noncharging compounds in order to maintain smooth operation and long life at all temperatures.

The outer sleeve is made in two separated sections, spring loaded for accurate positioning. The focusing lock, when applied, operates in the same direction as the loaded spring; thus, a rigid, exact station of focus is acquired. When the knurled lock ring behind the focusing ring is turned, the floating section of the sleeve is pushed away from the main stationary section, clamping the threads axially on the internal sleeve or screw.

These lenses are all flange focused on an internal flange. Consequently, there is no defacing of any outside surfaces. The trimming dimension is held within plus or minus 1/20 of 1%, to plus or minus 1/33 of 1%, depending on the particular focal length of the lens in the series. Special equipment had to be designed in order to measure and maintain these very close dimensions.

Provision has been made to add Depth of Field Scales when required.

A new design dust cap is provided (Table II). It is black molded cold-resistant synthetic rubber with a metal insert, giving the stiffness and protection of an all-metal cap and the grip of a rubber cap. Because of size standardization, each cap fits the lens with or without the sunshade.

Table II. Lens (Dust) Caps.

Size No.	For Diameters in.	mm
6	1.870	47.5
7	2.244	57.0
8	2.744	69.7

The following tabulation gives lens nomenclature, mount characteristics, and accessory sizes:

1-in. (*25.5mm*) *f/2* (*T2.2*)
Focuses from infinity to 1 ft
Iris calibrated from $f/2$ to $f/22$ (T2.2 to T22)
Filter size 6 ($1\frac{1}{2}$ in.)
Sunshade size 6–7
Cap size 7

1.4-in. (*35mm*) *f/2* (*T2.2*)
Focuses from infinity to 1.5 ft
Iris calibrated from $f/2$ to $f/22$ (T2.2 to T22)
Filter size 5 (1 in.)
Sunshade size 5–6
Cap size 6

2-in. (*50mm*) *f/2* (*T2.2*)
Focuses from infinity to 2.5 ft
Iris calibrated from $f/2$ to $f/22$ (T2.2 to T22)
Filter size 6 ($1\frac{1}{2}$ in.)
Sunshade size 6
Cap size 6

3-in. (*75mm*) *f/2* (*T2.2*)
Focuses from infinity to 5 ft
Iris calibrated from $f/2$ to $f/22$ (T2.2 to T22)
Filter size 7 (2 in.)
Sunshade size 7
Cap size 7

4-in. (*100mm*) *f/2* (*T2.2*)
Focuses from infinity to 4 ft
Iris calibrated from $f/2$ to $f/22$ (T2.2 to T22)
Filter size 8 ($2\frac{1}{2}$ in.)
Sunshade size 8
Cap size 8

6-in. (*152mm*) *f/3.5* (*T3.7*)
Focuses from infinity to 10 ft
Iris calibrated from $f/3.5$ to $f/22$ (T3.7 to T22)
Filter size 8 ($2\frac{1}{2}$ in.)
Sunshade size 8
Cap size 8

10 in. (*254mm*) *f/4.5* (*T4.9*)
Focuses from infinity to 25 ft
Iris calibrated from $f/4.5$ to $f/22$ (T4.9 to T22)
Filter size 8 ($2\frac{1}{2}$ in.)
Sunshade size 8
Cap size 8

In the design of these lenses, special engineering and manufacturing techniques have been applied, which insure concentricity. The factors contributing most to these goals are:

1. *The Optical Centering of the Elements:* Special equipment assures a high degree of accuracy in centering before and after cementing.

2. *The Alignment of the Elements in Their Cells:* The basic geometry of the thick edges, plus thick spacers, and the parallel seats, assure an optical-mechanical self-alignment with remarkable accuracy and without imposing impossible tolerances.

3. *The Smooth Fit of the Threads:* No threads are generated by taps and dies. Retaining ring threads are chased parallel and square to the bore.

4. *The Piloting of Cells and Focusing Mounts:* Where higher accuracy is required, pilots and threads are used. The threads only to retain, and the pilots to guide and locate. Operational threads are lapped.

All of this is obtained without a sacrifice to production possibilities. The parts are held to such precision that there is an absolute minimum of hand fit required, which in turn insures a production in keeping with any normal requirements that could be placed upon us within the realm of reason or economic limits.

Patents have been applied for on all of these lenses. Due to the newness of this development, sufficient time has not elapsed to receive patent office action.

While being currently supplied to the military services, it is felt that this series contains features of value to others and so will be commercially available.

The authors wish to give special commendations to the staffs of both General Scientific Corp. and Bell & Howell Co. for the splendid help in the design, development, testing and production of the Miltar lenses.

Discussion

John D. Hayes (Bausch & Lomb Optical Co.): I'd like to ask the authors how they obtained sealing for humidity around the iris diaphragm slot in the barrel?

Mr. Foote: There is no sealing for humidity. The operational requirements of the lens do not specify that in this particular case.

CORRECTION — PH22.11–1952
16Mm Motion Picture Projection Reels

In the process of revising Z22.11, several drafts were considered by the 16mm and 8mm Motion Pictures Committee. In December 1949, SMPE 121 was issued containing a misplaced decimal point in the lateral runout dimension of 200-ft reels (Table 2). Thus, the correct dimension of .057 in. was given as 0.57 in. This error was discovered only after the final approved standard was published in the June 1952 *Journal.* The standard is therefore now being republished as originally intended.

In addition, the diagram has been changed slightly to show the flanges flat instead of flared to preclude any misunderstanding that the edges must be rolled or flared. The words "if any" have been added at the end of the note after "S" in the table of dimensions to make that clear.

American Standard
for
16-Millimeter Motion Picture Projection Reels

ASA
Reg. U. S. Pat. Off.
PH22.11-1952
Revision of
Z22.11-1941
and
Z52.33-1945
*UDC 778.55

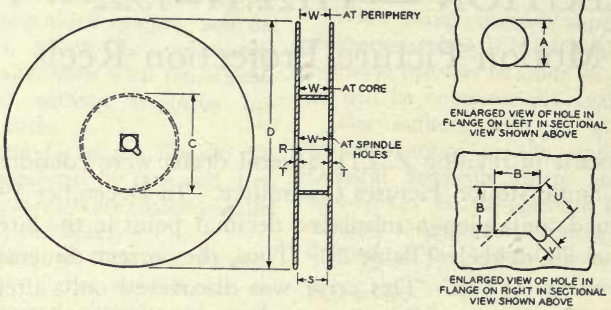


Table 1

See page 3 for notes.

Dimension	Inches		Millimeters	
A	0.319	+0.000 −0.003	8.10	+0.00 −0.08
B	0.319	+0.000 −0.003	8.10	+0.00 −0.08
R[1]	0.790	maximum	20.06	maximum
S[2] (including flared, rolled, or beveled edges, if any)	0.962	maximum	24.43	maximum
T (adjacent to spindle)	0.027 0.066	minimum maximum	0.69 1.68	minimum maximum
U	0.312	±0.016	7.92	±0.41
V	0.125	+0.005 −0.000	3.18	+0.13 −0.00
W, at periphery[3]	0.660	+0.045 −0.025	16.76	+1.14 −0.64
at core[4]	0.660	±0.010	16.76	±0.25
at spindle holes	0.660	±0.015	16.76	±0.38
Flange and core concentricity[5]	±0.031		±0.79	

Approved April 30, 1952, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

American Standard

for

16-Millimeter Motion Picture Projection Reels

ASA
Reg. U. S. Pat. Off.

PH22.11-1952

Table 2

Capacity	Dimension	Inches	Millimeters	Capacity	Dimension	Inches	Millimeters
200 feet[6] (61 meters)	D, nominal	5.000	127.00	1200 feet (366 meters)	D, nominal	12.250	311.15
	maximum	5.031	127.79		maximum	12.250	311.15
	minimum	5.000	127.00		minimum	12.125*	307.98*
	C, nominal	1.750	44.45		C, nominal	4.875	123.83
	maximum	2.000*	50.80*		maximum	4.875	123.83
	minimum	1.750	44.45		minimum	4.625*	117.48*
	Lateral runout,[7] maximum	0.057	1.45		Lateral runout,[7] maximum	0.140	3.56
400 feet[6] (122 meters)	D, nominal	7.000	177.80	1600 feet (488 meters)	D, nominal	13.750	349.25
	maximum	7.031	178.59		maximum	14.000*	355.60*
	minimum	7.000	177.80		minimum	13.750	349.25
	C, nominal	2.500	63.50		C, nominal	4.875	123.83
	maximum	2.500	63.50		maximum	4.875	123.83
	minimum	1.750*	44.45*		minimum	4.625*	117.48*
	Lateral runout,[7] maximum	0.080	2.03		Lateral runout,[7] maximum	0.160	4.06
800 feet (244 meters)	D, nominal	10.500	266.70	2000 feet (610 meters)	D, nominal	15.000	381.00
	maximum	10.531	267.49		maximum	15.031	381.79
	minimum	10.500	266.70		minimum	15.000	381.00
	C, nominal	4.875	123.83		C, nominal	4.625	117.48
	maximum	4.875	123.83		maximum	4.875	123.83
	minimum	4.500*	114.30*		minimum	4.625	117.48
	Lateral runout,[7] maximum	0.120	3.05		Lateral runout,[7] maximum	0.171	4.34

*When new reels are designed or when new tools are made for present reels, the cores and flanges should be made to conform, as closely as practicable, to the nominal values in the above table. It is hoped that in some future revision of this standard the asterisked values may be omitted.

Note 1: The outer surfaces of the flanges shall be flat out to a diameter of at least 1.250 inches.

Note 2: Rivets or other fastening members shall not extend beyond the outside surfaces of the flanges more than 1/32 inch (0.79 millimeter) and shall not extend beyond the over-all thickness indicated by dimension S.

Note 3: Except at embossings, rolled edges, and rounded corners, the limits shown here shall not be exceeded at the periphery of the flanges, nor at any other distance from the center of the reel.

Note 4: If spring fingers are used to engage the edges of the film, dimension W shall be measured between the fingers when they are pressed outward to the limit of their operating range.

Note 5: This concentricity is with respect to the center line of the hole for the spindles.

Note 6: This reel should not be used as a take-up reel on a sound projector unless there is special provision to keep the take-up tension within the desirable range of 1½ to 5 ounces.

Note 7: Lateral runout is the maximum excursion of any point on the flange from the intended plane of rotation of that point when the reel is rotated on an accurate, tightly fitted shaft.

American Standard for 16-Millimeter Motion Picture Projection Reels	ASA Reg. U. S. Pat. Off. PH22.11-1952

Appendix

(This Appendix is not a part of the American Standard for 16-Millimeter Motion Picture Projection Reels, PH22.11-1952.)

Dimensions A and B were chosen to give sufficient clearance between the reels and the largest spindles normally used on 16-millimeter projectors. While some users prefer a square hole in both flanges for laboratory work, it is recommended that such reels be obtained on special order. If both flanges have square holes, and if the respective sides of the squares are parallel, the reel will not be suitable for use on some spindles. This is true if the spindle has a shoulder against which the outer flange is stopped for lateral positioning of the reel. But the objection does not apply if the two squares are oriented so that their respective sides are at an angle.

For regular projection, however, a reel with a round hole in one flange is generally preferred. With it the projectionist can tell at a glance whether or not the film needs rewinding. Furthermore, this type of reel helps the projectionist place the film correctly on the projector and thread it so that the picture is properly oriented with respect to rights and lefts.

The nominal value for W was chosen to provide proper lateral clearance for the film, which has a maximum width of 0.630 inch. Yet the channel is narrow enough so that the film cannot wander laterally too much as it is coiled; if the channel is too wide, it is likely to cause loose winding and excessively large rolls. The tolerances for W vary. At the core they are least because it is possible to control the distance fairly easily in that zone. At the holes for the spindles they are somewhat larger to allow for slight buckling of the flanges between the core and the holes. At the periphery the tolerances are still greater because it is difficult to maintain the distance with such accuracy.

Minimum and maximum values for T, the thickness of the flanges, were chosen to permit the use of various materials.

The opening in the corner of the square hole, to which dimensions U and V apply, is provided for the spindles of 35-millimeter rewinds, which are used in some laboratories.

D, the outside diameter of the flanges, was made as large as permitted by past practice in the design of projectors, containers for the reels, rewinds, and similar equipment. This was done so that the values of C could be made as great as possible. Then there is less variation, throughout the projection of a roll, in the tension to which the film is subjected by the take-up mechanism, especially if a constant-torque device is used. Thus it is necessary to keep the ratio of flange diameter to core diameter as small as possible, and also to eliminate as many small cores as possible. For the cores, rather widely separated limits (not intended to be manufacturing tolerances) are given in order to permit the use of current reels that are known to give satisfactory results.

72d Semiannual Convention

The Tentative Program, mailed to all members on August 29, shows the schedule for 86 papers and Committee Reports. Sixteen Committee Meetings will be held during the week. Of the 86 papers, 41 are for the International Symposium on High-Speed Photography which is scheduled to begin on Wednesday morning, October 8, with successive sessions originally scheduled through Friday forenoon. Current developments may require Program Chairman Joe Aiken to revise this so that the Symposium is carried through Friday afternoon. In that case, the last three papers scheduled for Thursday afternoon at the Naval Ordnance Laboratory may be moved to a Symposium session, and certain special motion picture papers would be scheduled for the Naval Ordnance Laboratory Session. For the NOL Session, note this advice repeated from the Tentative Program:

All individuals who wish to go on the trip to the Naval Ordnance Laboratory on Thursday, must register for it prior to noon Tuesday, October 7. Those who wish to attend this session, but who cannot register before noon Tuesday, must write their intention to Joseph E. Aiken, 116 N. Galveston St., Arlington 3, Virginia, and state if they are citizens of the United States.

All non-citizens of the United States must receive a special clearance for the Naval Ordnance Laboratory visit. This may be obtained by writing to their embassy in Washington, prior to the Convention, requesting that they be cleared for this visit to the Chief of Naval Operations, who will in turn notify the Naval Ordnance Laboratory.

Plans for the first two days remain essentially the same as in the Advance Postal Card Notice — Television Sessions on Monday afternoon and evening and on Tuesday forenoon and afternoon, and a General Motion Pictures Session Tuesday evening.

Those who do not yet have hotel reservations should write Air Mail or wire Mr. H. C. Blunck, Manager, Hotel Statler, Washington, D.C. Ask Society headquarters for information or copies of the Tentative Program if you would like such.

Board of Governors Meeting

A major portion of the Society's Board Meeting on July 17 was a continuation and reflection of what was previously reported as "Most significant administrative development of 1951 . . ." (report of this year's first Board Meeting). This has been the appointment and operation of an Executive Committee.

From the Executive Committee's attention to some major details and aspects of the Society's operation have come logically and with minimum pain several summations of points of policy for the Board's consideration. The Board also reviewed the initial outline of a study of the costs of membership service and of the costs of securing new members. Action was taken on the resignation of one Society Officer and policy was carefully reviewed in regard to another office.

The Executive Committee has been studying and reviewing some legal problems, accounting policies, test film operations and possibilities for a project control scheme that would formalize the course of Society projects. These Board actions have resulted in Proposed Bylaws.

One proposed additional Bylaw records the long-established underlying policy that Standards and Recommendations developed by the Society are of a voluntary nature. The other Bylaw meets the legal technicality of providing for a procedure for disposition of assets in case of dissolution. These proposals were explained in detail in the August *Journal*, p. 153.

Test Films

The Board reaffirmed the Society's policy of developing and supplying test films on a no-profit, no-loss basis. The appropriate officers and employees were instructed to make whatever cost accounting analyses, surveys and sales forecasts are necessary to maintain the policy of supply-

ing test films as a part of the Society's general program for the development of technical and engineering standards.

Membership Cost Study

The Executive Secretary presented a brief report of progress on the Headquarters' cost study of membership service, explaining that this first official attempt to separate the Society's various operations for the purpose of cost analysis was encouraging. Comparisons were drawn between dues paid by the average member and cost of services rendered, and then between the first year's dues of a new member, the cost to secure each additional new member, and the added cost to the Society of services rendered to a new member during his first year. It is expected that the completed study will be the basis for detailed planning of the many Society activities.

Finances and Budget

The six-month reports of the Financial Vice-President and the Treasurer were approved. The Executive Secretary made a preliminary report on the 1953 budget, and the Board made recommendations as the basis for further budget planning, so that a proposed 1953 budget can be considered at its next Meeting. The initial budget planning was based on the advice of the officers of five groups of activities: engineering, conventions, publications, sustaining memberships, and general membership promotion. They were asked for their advice for 1953 compared with 1952 and the three preceding years. Expense items which are policy-controlled were the subjects of study.

Resignation of F. T. Bowditch

Mr. Bowditch had reported to the Society's President on June 13 that an emergency situation at National Carbon Company required his attention to new duties and his relinquishing the Society's Engineering Vice-Presidency. The Board regretfully accepted the resignation to be effective October 6 and appointed Henry J. Hood of Eastman Kodak to serve from October 6, 1952, through December 31, 1953. Something of the scope of Mr. Bowditch's service to the Society is given later in this *Journal* under "Engineering Activities," and in the report opening this *Journal*.

Nominations and Other Reports

With one exception, the roster of nominees for the Society's 1952 election was all cleared and was approved by the Board.

For the first time in 36 years there has had to be a change in the nominee for Convention Vice-President. The Nominating Committee had cause for pause: since 1916, the Society has had "Conventions by Bill Kunzmann"—so the Committee tossed into the lap of the Board the poser created by Bill Kunzmann's forthcoming retirement from National Carbon. The Board discussed at great length possibilities for revising the duties and lessening the travel and other demands made on the Convention Vice-President, but it was not possible within the long-established policies of the Society to work out a program that would enable Bill to accept the nomination. The Board, therefore, regretfully turned to the alternative of seeking another nominee and gave the job of finding someone to the Executive Vice-President and a committee of four. A number of suggestions were received and the final choice made was Jack Servies, Vice-President of National Theatre Supply. The nomination of Mr. Servies was approved by a letter ballot of the Board and his name completed the roster for the ballots which were mailed on August 25 to all voting members.

Reports of the Fellow Award and other award committees were received and approved. A complete account of awards will be given in a later *Journal*. Malcolm G. Townsley as chairman of a temporary committee to study the method of presenting awards reported that his group favored making all the presentations at the banquet. An informal report from John G. Frayne, Chairman of the 75th (Spring of '53) Convention Planning Committee, briefly described the program, which is to be based on an historical theme, with the likely extra costs for such a project being partially offset by sales of a proposed booklet. Important developments in motion pictures and television over the past fifty years would be covered in several technical sessions, with particular papers covering the field from the beginning to the very latest along technical lines.

Other reports approved were those of the Convention Vice-President, Editorial Vice-President and the three Section Chairmen.

Engineering Activities

Engineering Vice-President

Fred Bowditch, the Society's active and able Engineering Vice-President, has submitted his resignation, effective October 6, 1952. An increase in his responsibilities with National Carbon Co. no longer allows the time and attention that he feels the Engineering Vice-Presidency requires.

Long active in the engineering and standards work of the Society, Fred was elected Engineering Vice-President for 1950–52 and reelected for 1952–54. The diversity of his Society interests is indicated in the listing below, but this in no way begins to tell the story of the vital contributions he has made to the present healthy state of our engineering activities.

Committee	*Period*
Color	1940–44
Inter-Society Color Council	1940–52
Papers	1941–44
Progress	1941–45
Screen Brightness	1941
Standards, Chairman 1940–47	1941–52
Z22 (PH22), Chairman 1949–50	1946–52
Television	1947–49
Board of Governors	1949–52
Nominations	1949–52
Fellow Award	1950–52

We know that through his continued membership on several of the above committees he will maintain his close contact with the Society.

His successor will be Henry Hood of Eastman Kodak. Henry started his committee activity in 1945 as a member of the Non-Theatrical Equipment Committee. This was reorganized in 1948 as the Committee on 16mm and 8mm Motion Pictures with Henry as chairman. The committee blossomed under his leadership and in 1950 he was reappointed for a second two-year term, the maximum permitted by the Bylaws. At the conclusion of his second term and in recognition of his outstanding work, he was appointed Chairman of the Standards Committee. At the last meeting of the Board of Governors, July 17, Henry was appointed to complete the remainder of Fred's term of office.—*Henry Kogel*, Staff Engineer.

Atlantic Coast Section Regional Meeting at Atlanta

The Regional Meeting of the SMPTE Atlantic Coast Section held on Friday, May 9, in Atlanta, Ga., as a joint endeavor with the Atlanta Section of the IRE and the Atlanta Chapter of the AIEE, attracted an attendance of over 200 in the Hightower Textile Building Auditorium of the Georgia Institute of Technology. The arrangements for the meeting were made by E. M. Stifle, Chairman of the Atlantic Coast Section, assisted by Charles D. Beeland and Ben Akerman, both of Atlanta.

The program was:

Comparison of Definition in Television and Photographic Processes by Otto H. Schade, Tube Dept., Radio Corporation of America, Harrison, N.J.

Eastman Color Motion Picture Films by W. T. Hanson, Jr., Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.

Synchro-Lite Powered 16mm Film Projector for Television by R. E. Putnam and E. H. Lederer, Broadcast Studio Engineering Sec., Electronics Div., General Electric Co., Syracuse, N.Y.

Improved Television Film Reproduction by Vernon J. Duke and K. E. Mullenger, National Broadcasting Co., New York, *presented by* C. F. Daugherty, WSB-TV, Atlanta, Ga.

Lighting for Television, a film, by courtesy of CBS-TV, New York, produced by Paul Wittig and directed by Lela Swift.

Great interest was shown in this meeting. A number of requests have come in from persons who attended this meeting, asking for more similar meetings to be held in Atlanta. In addition to the large attendance from Georgia, engineers also came from the states of Alabama, Illinois, New Jersey, New York, South Carolina and Tennessee. — *E. M. Stifle*, Eastman Kodak Co., 342 Madison Ave., New York 17, N.Y.

Letters to the Editor

Re: Stereoptics Ltd. Cameras for Telecinema Film

My attention has been drawn to the article by Mr. R. Spottiswoode which appears in the April 1952 *Journal.*

In order to correct any misunderstanding which may, perhaps, have arisen in the minds of some readers, I would like to draw attention to the following points which Mr. Spottiswoode — no doubt unintentionally — has omitted to mention.

The principle of the stereo photographic equipment, embodying two cameras, supplied for the production of stereo films for the Festival of Britain Telecinema, was devised by the undersigned and the apparatus was supplied by one of my Companies—Messrs. Stereoptics Ltd. of London. Moreover, the principle involved is the subject of British Complete Patent Application No. 17,086/50 which, it is understood, is due for acceptance at an early date.

A full description of the apparatus was given in my paper "Stereoscopy in the Telekinema and in the Future" which I produced last year at the request of the British Kinematograph Society and which was published in that Society's Journal, *British Kinematography, 18:* pp. 172–181, No. 6, June 1952.

June 17, 1952

L. Dudley, Director
Stereoptics, Ltd.
Odeon Theatre
263 Kensington High St.,
London, W. 8, England

Note by Raymond Spottiswoode

One out of the four Telecinema pictures, *A Solid Explanation*, was shot with the aid of two film cameras of well-known make, mounted on a special base incorporating the patent Mr. Dudley refers to and designed and built under his company's direction. This film carries the credit title, "The equipment, incorporating cameras by Newman and Sinclair, Ltd., was developed by Stereoptics, Ltd."

July 12, 1952

Raymond Spottiswoode
Kingsgate
Sudbury Hill
Harrow-on-the-Hill
England

Book Reviews

Classrooms

No. 1 in a series, *Planning Schools for Use of Audio-Visual Materials.* Published (1952) by Department of Audio-Visual Instruction, National Education Association, 1201 Sixteenth St., N.W., Washington, D.C. 40 pp. 20 illus. Paper covered. 6 × 9 in. Price $1.00.

This is the first of a series of booklets on planning schools for the use of audio-visual aids.[1] Devoted entirely to the planning of classrooms for greatest efficiency, it is prepared as a guide to architects and other planners who are designing new schools or remodeling old classrooms. Various planning groups and manufacturers of audio-visual materials collaborated in preparing the text.

[1] D. F. Lyman, "Audio-Visual Instruction Conference," *Jour. SMPTE,* 58: 445–449, May 1952.

The introduction states that it is generally recognized that the use of audio-visual materials greatly enriches the child's classroom education. Thus it prepares him better to meet the demands of the modern world. But it is not so well recognized that school buildings must be planned carefully by administrators, architects, faculties, patrons and builders, or the audio-visual program will be quite ineffective if not impossible. The classroom is considered in this first study because it is the first and most important part of the building to equip properly.

By far the chief function of the book is to describe methods of darkening the classroom to insure good tonal quality in the projected picture. Several ways of darkening the room are described: drapes, opaque shades, venetian blinds, louvres and jalousies. Drawings and photographs of

actual installations clarify the text. Of great practical value is the list of 36 companies that produce or distribute materials for this purpose.

One short section describes the requirements for adequate ventilation of the darkened classroom. Other sections show the proper ways to select, mount and use the projection screen. There are specifications for projection stands, placement of loudspeakers, switches, receptacles, and conduits to connect the classroom with the central sound and television system. A brief section on acoustics states the fundamental problems simply and clearly, with references to other authorities for more detailed information.

Specifications for display facilities and project areas for small groups emphasize the importance of considering other audio-visual aids. Another short section deals with facilities for storing equipment. One of the appealing characteristics of this booklet is that it describes in broad terms the general requirements for good results — and the best methods of obtaining them — but does not go into burdensome detail.

The final section describes the steps required to achieve the goals previously outlined, focusing the attention of all planners on the activities for which provision should be made, and getting all to support the program. Teachers, particularly, should be consulted. A final paragraph invites comments from readers who need more information or have additional ideas to share with others. A bibliography cites 26 articles and books on subjects relating to this problem.

In view of the large number of schools now being planned or remodeled, and in view of the demonstrated need for a better understanding of the requirements for audio-visual aids, this booklet should be given immediate, wide circulation among those who plan classrooms.—*D. F. Lyman*, Development Dept., Camera Works, Eastman Kodak Co., Rochester 4, N.Y.

Proceedings of the London Conference on Optical Instruments 1950

(Held at Imperial College, London, July 1950.) Published (1952) by John Wiley & Sons, 440 Fourth Ave., New York 16. i-xv + 256 pp. + 8 pp. index. 100 illus. 5 × 8 in. Price $7.00.

Kingslake reviews recent developments in photographic lenses under high index glasses, double-, triple- and four-element systems, high aperture, Petzval types, wide angle, telephoto, afocal, zoom, catadioptric system, increased depth of field, aspheric surfaces, mechanical improvements and other materials. Over 170 patents, not counting duplicates in other countries, have issued on photographic lenses since 1940. H. H. Hopkins discusses the zoom lenses as symmetrical systems of variable power. Improvements possible in high aperture lenses having spherical fields (curved film) are discussed by Warmisham. The remaining five-sixths of the report covers reflecting microscopes, gratings and their instruments, phase microscopes, spectrophotometers, reflecting telescopes, miscellaneous (velocity of light and measurement of distance; photometry of optical instruments), and new optical materials. This is a good summary of the status in 1950 and gives a fairly complete coverage in a small space. The references provided will meet the immediate need for more detail in each field. Progress has come mainly from the newer glasses of high index and lower dispersions allowing the designer to use simpler constructions, although a few items reveal progress from human ingenuity.—*O. W. Richards*, American Optical Company, Stamford, Conn.

Technical Optics (Vol. II)

By L. C. Martin. Published (1950) by Pitman, 2 W. 45 St., New York 19. 327 pp. + 12 pp. appendix + 4 pp. index. Approx. 260 illus. $5\frac{1}{2} \times 8\frac{1}{2}$ in. Price $7.50.

Like most books on technical optics this volume follows the regular pattern, having one chapter on single lenses and magnifiers followed by a chapter each for telescopes, magnifiers, photographic lenses, and the testing of optical instruments. In each chapter the historical development is followed by some of the technical questions encountered in the design of optical instruments.

Related topics are the subject of chapters on binocular vision and binocular instruments, photometry (where projection systems and projectors are briefly described),

and aspheric surfaces. In the latter chapter, Schmidt systems and other recent high-speed aspheric systems which are of interest to the projection of television images are discussed. In four appendixes, symbols, defraction gratings, chromatic abberation of thin lenses, and data on seven photographic lenses are given.

The publisher states, "the book is of the greatest value to scientific instrument makers, ophthalmic opticians, spectacle makers, and students." The technical descriptions and derivations do not make this book easy to read for the casual reader but rather a book for the student and scientific user of optical instruments. Even though it can serve as a useful reference or study book of technical optics it cannot be classified as a treatise on the subject. A great majority of the references are to British works and authors, and little mention is made of work done in other countries.

Engineers and physicists dealing with the design of optical instruments will find this book a valuable addition to their library. Other American readers who want an insight into this branch will, no doubt, prefer *Fundamentals of Optical Engineering* by D. H. Jacobs, or *The Principles of Optics* by A. C. Hardy and F. H. Perrin.—*Dr. John L. Maultbesch*, Vice-President, Kollmorgen Optical Corp., 347 King St., Northampton, Mass.

Focal Cinebooks

A special series of inexpensive, popular monographs on motion picture subjects, consisting of the following:

How to Script, by Oswell Blakeston, 1st ed., 1949
How to Film, by G. Wain, 3d ed., 1952
How to Direct, by Tony Rose, 1st ed., 1949
How to Edit, by H. Baddeley, 1st ed., 1951
How to Act, by Tony Rose and Martin Benson, 1st ed., 1951
How to Process, by Leslie J. Wheeler, 1st ed., 1950
How to Title, by L. F. Minter, 1st ed., 1949
How to Project, by Norman Jenkins, 2d ed., 1951
How to Cartoon, by John Halas and Bob Privett, 1st ed., 1951
How to Use 9.5mm, by D. M. Neale, 1st ed., 1951

Published by Focal Press Ltd., 31 Fitzroy Sq., London, W. 1, England. Paper bound. Price 7s. 6d.

This series of popular monographs is, in a sense, the motion picture counterpart to Focal Press' famous series of basic booklets in still photography. However, for the "still" series the titles were characterized by the two-word prefix "All About" instead of "How to," as in the present series. The general level of the motion picture booklets is considerably more advanced than that established for the still booklets; nevertheless, by no stretch of the imagination can the motion picture booklets be recommended to the specialist, except possibly to the extent that a specialist in one field might find the booklets on subjects outside his respective field worth reading. For example, a director or film editor could derive some insight into the complexities of processing by a reading of *How to Process.* But he would gain a false impression of modern motion picture laboratory practice if he went no further, for the booklet treats the subject entirely from a standpoint of home processing on old-fashioned drums.

The booklets generally are well written and thoroughly illustrated. They are obviously directed to the serious amateur who wants to improve his film results and dabble in home laboratory procedures.—*Lloyd E. Varden*, Pavelle Color, Inc., 533 W. 57 St., New York 19, N.Y.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal.*

Positions Wanted

Production, TV or Motion Picture: NYU BA in motion picture and TV production; participated in productions as director and unit mgr; experience as motion picture sensitometrist; at present motion picture negative assembler and cutter; worked swing shift while attending college; licensed 35mm projectionist; single, 29, veteran, resume on request; go anywhere. Harold Bernard, 560 Eastern Pkwy, Brooklyn 25, N.Y.

TV Producer-Director: Now Chief of Production in Army's first mobile TV system; military experience in writing-directing high-speed, low-cost instructional productions; formerly TV producer-director, KRON-TV San Francisco, five shows weekly; will be separated from service Nov. 1952; desire connection in educational TV, preferably employing kinescope techniques; married; prefer West Coast, but willing to travel; résumé, script samples, pictures of work — on request; 1st Lt. Robert Lownsbery, SigC Mbl TV Sys, c/o Sig Photo Center, 35-11 35th Ave., Long Island City 1, N.Y.

Journals Available and Wanted

Available

Upon a reasonable offer to Alfred S. Norbury, 3526 Harrison St., Kansas City 3, Mo.:

Vol. 44 (Jan.-June 1945)	Vol. 50 (Jan.-June 1948)
Vol. 45 (July-Dec. 1945)	Vol. 51 (July-Dec. 1948)
Vol. 47 (July-Dec. 1946)	Vol. 52 (Jan.-June 1949)
Vol. 48 (Jan.-June 1947)	Vol. 56 (Jan.-June 1951)
Vol. 49 (July-Dec. 1947)	Vol. 57 (July-Dec. 1951)

A set of Journals from January 1945 through 1951 at $15.00 plus packing and carrying costs from Richard W. Maedler, 32–52 — 46 St., Long Island City 3, N.Y.

Complete set, in excellent condition, from January 1930 to date, plus one issue of September 1928 from Don Canady, 5125 Myerdale Drive, R.R. 15, Cincinnati, 36, Ohio.

5 years (1947–51) in perfect condition plus the indexes for 1936–45 and 1946–50 and including the 1949 High-Speed Photography, upon any reasonable offer to Vic Gretzinger, 3547 Suter St., Oakland 19, Calif.

Transactions Nos. 11, 14, 20, 21, 23, 25, 27, 28 and 38; and 22 years of the *Journal* (1930–1951) except for Jan., Feb., Mar. and Apr. of 1934, Jan. and Apr. of 1948, and Feb. 1950; also these extra single copies — Nov. 1930; Jan., Feb., July and Nov. 1931; June 1932; Mar. and Apr. 1933; Dec. 1934; Jan. and May 1935; Oct. 1938; July and Dec. 1940; Oct. 1948 and Jan. 1950, upon any reasonable offer made to Paul J. Larsen, Assistant to the President, Borg-Warner Corp., 310 So. Michigan Ave., Chicago 4, Ill.

Wanted

Transactions 1, 6 and 7. Contact Mrs. Dorothy Gelatt, Henry M. Lester, 101 Park Ave., New York 17, N.Y.

High-Speed Photography, Volume 1, reprint or original Journal, March 1949, Part II, by John H. Waddell, Wollensak Optical Co., 850 Hudson Ave., Rochester 21, N.Y.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 MEMBERSHIP DIRECTORY.

Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

Barker, Lovell H., Film Processing Laboratory Owner. **Mail:** 9208 Memorial, Detroit 28, Mich. (M)

Bernstein, Paul, TV Studio Technician and Engineer, WOI-TV, Iowa State College, Ames, Iowa. (A)

Blanchard, Vernon W., Chemist, E. I. Du Pont de Nemours & Co., Photo Products Dept. **Mail:** 42 South Drive, Lawrence Brook Manor, Rt. 9, New Brunswick, N.J. (A)

Bostwick, James W., Manager, Motion Pictures & Slide Films, General Motors Photographic, General Motors Corp., B-120 GM Bldg., Detroit 2, Mich. (M)

Brasier, C. S., Scientific Photographer, Ministry of Supply, British Government. **Mail:** 4 Romney Rd., Southcourt, Aylesbury, Bucks, England. (A)

Carter, Bryan, Chief Electrician, Universal Pictures Co., Universal City, Calif. (M)

Chessman, Walter E., Jr., Mechanical Engineer, Alexander Film Co. **Mail:** 1516 Vista Pl., Colorado Springs, Col. (A)

Coan, Edward M., Television Engineer, Allen B. DuMont Laboratories, Inc. **Mail:** 37 Overlook Rd., Cedar Grove, N.J. (M)

Cook, George R., Treasurer, Radio Station WLS. **Mail:** 1419 Lathrop Ave., River Forest, Ill. (M)

Cotcher, Alfred L., Electronic Scientist, National Bureau of Standards. **Mail:** 3410 Highview Ct., Wheaton, Md. (A)

Dobbs, Frank S., Manufacturer, Cine Products Supply Corp., Ashland, N.J. (M)

Drucker, Donald, Motion Picture Film Editor, Charles R. Sene. **Mail:** 6804 — 18 Ave., Brooklyn, N.Y. (A)

Faithorn, Nathaniel R., Television Engineer, The Associated Broadcasters, Inc. **Mail:** 430 Myra Way, San Francisco 16, Calif. (A)

Filmer, Philip, General Manager, General Motors Photographic, General Motors Corp., 407 General Motors Research Bldg., Detroit, Mich. (M)

Green, Phil C., Television Engineer, WSM Television. **Mail:** 4112 Rockdale Ave., Nashville, Tenn. (A)

Hewins, Leonard J., Manager, Mole-Richardson (Spain). **Mail:** Garcia Morato 121, Madrid, Spain. (M)

Huffman, Robert L., Mechanical Engineer, Automatic Electric Co. **Mail:** 1033 W. Van Buren St., Chicago 7, Ill. (A)

Karo, James, Photographic Supervisor, Sandia Corp. **Mail:** 1123 Silver Ave., S.W., Albuquerque, N.M. (A)

Keller, John S., Supervisor, Field Optical Installations, Sandia Corp. **Mail:** San Felipe Lodge, Apt. 201, Salton Sea Base, Westmorland, Calif. (M)

Koch, William A., Chemist, Eastman Kodak Co., 342 Madison Ave., New York 17, N.Y. (M)

Lenz, Irvin W., High-Speed Motion Picture Camera Technician, Sandia Corp., Field Test Dept., Sandia Base, Albuquerque, N.M. (A)

Macauley, Alan C., 16mm Production and Distribution, World Films. **Mail:** Box 72, Sierra Madre, Calif. (A)

Marcus, Paul, Chief Engineer, Partner, Bell Recording Co., 112 W. 89 St., New York 24, N.Y. (A)

Matt, Richard J., Producer, Box 581, Fond du Lac, Wis. (M)

McNaughten, Neal, Director of Engineering, National Association of Radio and Television Broadcasters, 1771 "N" St., N.W., Washington 6, D.C. (M)

Moore, Charles S., Supervisor of Sound Engineers, Radio Corporation of America. **Mail:** 6703 Starling Cir., Dallas, Tex. (A)

Pendreigh, Harold A., Projectionist, J. Kelly and R. Pannett. **Mail:** 88 George St., Rockhampton, Queensland, Australia. (A)

Peterson, Harry, Cinematographer, Atlas Film Corp. **Mail:** 411 Marion St., N., Oak Park, Ill. (M)

Rafalon, Jules, Mechanical Engineer, Assistant Chief, Pathe Laboratories, Inc., 105 E. 106 St., New York 29, N. Y. (M)

Read, Edmond C., Jr., Kinescope Recording Engineer, National Broadcasting Co. **Mail:** 4038 Michael Ave., Venice, Calif. (M)

Reiter, Samuel S., New York University. **Mail:** 1937 E. 37 St., Brooklyn 34, N.Y. (S)

Richardson, Robert W., Motion Picture Writer, Photographer and Producer, Barber-Greene Co., 400 Highland Ave., Aurora, Ill. (M)

Rowe, Thomas L., Chief Engineer, Radio Station WLS. **Mail:** 2324 W. Lunt, Chicago 45, Ill. (M)

Ruberg, Elden E., Sound Technician, Radio Corporation of America. **Mail:** 1039 Hartzell St., Pacific Palisades, Los Angeles, Calif. (A)

Strauch, Frederic P., Jr., Sales Engineer, Bell & Howell Co. **Mail:** 1122 Dartmouth, Wilmette, Ill. (A)

Wilner, John, Director of Engineering, Hearst Corp., 2610 N. Charles St., Baltimore 18, Md. (A)

Wilson, Ralph J., Supervisor, Photo Section, Sandia Corp. **Mail:** 295 C St., Brawley, Calif. (A)
Winkler, Edward A., Chemical Engineer, Eastman Kodak Co., 342 Madison Ave., New York 17, N.Y. (M)
Wolf, George E., Assistant Production Manager, Murphy-Lillis Productions, Inc. **Mail:** 3 Glenwood St., Little Neck, L.I., N.Y. (A)
Wood, Donald M., In Charge of Research Photography, Bendix Aviation Corp. **Mail:** 10410 E. Jefferson, Detroit 14, Mich. (A)
Zaccardi, Sgt. Carmie M., Motion Picture Photographer, U.S. Air Force, Box 494, Hq. AFFTC, Edwards Air Force Base, Edwards, Calif. (A)
Zost, Elmer G., Chemist, Alexander Film Co., Alexander Film Bldg., Colorado Springs, Col. (A)

CHANGES IN GRADE

Drew, R. O., (A) to (M)
Foster, John C., (A) to (M)
Gawel, Eugene W., (S) to (A)
Paramasivaiah, P., (S) to (A)

Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer
vol. 33, June 1952
Economy Set Lighting With Cone Lights (p. 248)
Camera Heater for Cold-weather Filming (p. 250) *R. Lawton*
vol. 33, July 1952
Stereo Movies Without Spectacles (p. 295) *A. D. Roe*
Filters in Cinematography (p. 296) *J. Forbes*
Electronic-Photo Recording—New TV Filming Method (p. 298) *C. L. Anderson*

Bild und Ton
vol. 5, May 1952
Die transportable Riffelwand (p. 150) *G. Hoffmann*
Warum zerspringen Stufenlinsen? (p. 136) *H. Jentzsch*
Mikrofotografie im Dienste der Kreislaufforschung (p. 139) *G. Vogel*

British Kinematography
vol. 20, May 1952
Problems of Storing Film for Archive Purposes (p. 150) *H. G. Brown*

Electronic Engineering
vol. 24, July 1952
Some Convertor Tubes and Their Applications (p. 302) *J. A. Jenkins and R. A. Chippendale*
A Method of Measuring Television Picture Detail (p. 308) *G. G. Gouriet*

Electronics
vol. 25, June 1952
Pack-Carried Television Station (p. 98) *L. E. Flory, W. S. Pike, J. E. Dilley and J. M. Morgan*
Self-Focusing Picture Tube (p. 107) *A. Y. Bentley, K. A. Hoagland and H. W. Grossbohlin*

Kino-Technik
no. 5, May 1952
Deutsche Ausfuhr von Kino-Film rollt langsam an (p. 101)
Geiselgasteig ist für den Farbfilm gerüstet (p. 102)
Das Bild der deutschen Filmwirtschaft—gestern und heute (p. 105) *A. N. Narath*
Welche Anforderungen stellt das Fernsehen an den Rohfilm? (p. 114)
Störungen bei der Vorführung von Farbfilmen (p. 117) *K. Braune and H. Tümmel*
no. 6, June 1952
Welche Anforderungen stellt das Fernsehen an den Rohfilm? (p. 149)
Störungen bei der Vorführung von Farbfilmen (p. 151) *K. Braune and H. Tümme*

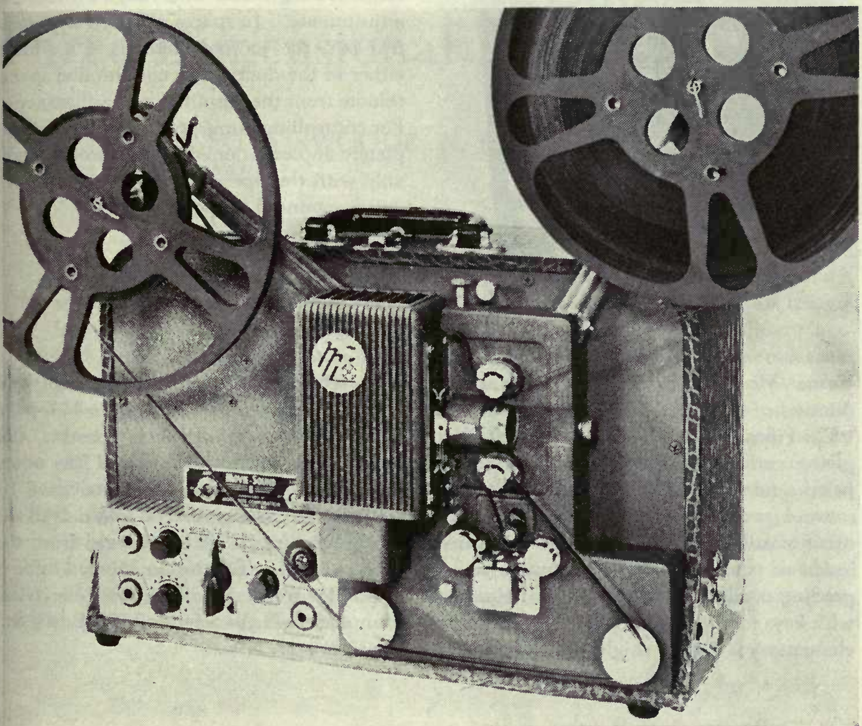
Radio & Television News
vol. 47, June 1952
(Radio-Electronic Engineering Section)
What's Ahead for Small-Town Television? (p. 31) *N. Sklarewitz*

Radio & Television News
vol. 48, July 1952
Improved Intercarrier Sound System (p. 36) *W. H. Buchsbaum*
Unique Magnetic-Tape Applications (p. 38) *L. A. Wortman*
Pulses in Sound Reproduction (p. 59) *G. Southworth*

Tele-Tech
vol. 11, Aug. 1952
Eidophor Projector for Theatre TV (p. 112)

New Products

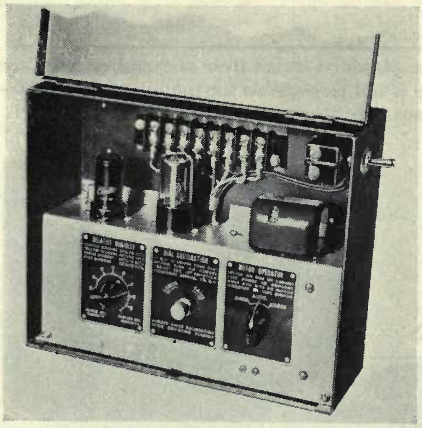
Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



Movie Sound 8 is the first commercially available equipment for recording and reproducing magnetic sound on 8mm film. The equipment comes in a single case, including a built-in 6-in. speaker and a microphone, and is marketed at $398.50 by Movie Mite Corp., 1105 Truman Rd., Kansas City 6, Mo. Magnetic striping of 8mm film is now available at 3½¢ a foot from Reeves Soundcraft Corp., 10 E. 52 St., New York 22, N.Y.

Movie Mite Corp. felt that an entirely new projector should be designed to get sound successfully on 8mm, chiefly to overcome wow and flutter problems and to provide 24 frame/sec sound speed and also the old, silent speed. To avoid sprocket hole modulation, a system called the Roto-Magnetic Stabilizer was developed to allow scanning the film in a flat plane. The use of a slightly tapered sound drum provides a substantial amount of the edge guiding needed. There are only two sprockets. They are driven by a worm gear connected by a rubber belt to the motor.

The standard projector has two input positions — for the record player and for the microphone. A small mixer is available for the operator who wishes to record from two records and a microphone. It is not necessary to use special film stock. Old 8mm films as well as new can be given the 25-mil magnetic stripe which is placed outside the perforations.



New electronic humidity controls are described in Bulletin F-5173 recently issued by Barber-Colman Co., Rockford, Ill. It is called two-position and proportioning for process or comfort control. It is a plug-in element designed for wide range with simple adjustments. In spaces supplied by a central fan, the sensing element is mounted either in the duct or the conditioned space, remote from the amplifier and adjustments. For controlling humidity in spaces not completely air conditioned, the control is available with the operating adjustment mechanism mounted in a cabinet.

Nema Movie Guide — 1952 is a compilation of complete data on "16mm Electrical Films." The Guide covers 409 films giving running time, color, sales or rental prices, release dates when ascertainable, sources (producer or chief distributor, with other possibilities covered in an extensive index of producers and distributors), and grading of films when that was obtainable, with keys for: guide or manual; primary; elementary; junior high school; senior high school; college; trade school and trade; and adult education. A 6-page "Classification by Subjects" makes this Guide very useful. It should be noted that there is only one film distributed by NEMA — *Installing Armored Cable.* All the other 408 films must be ordered from the sources listed. The Nema Movie Guide is available from the National Electrical Manufacturers Association, 155 E. 44 St., New York 17, N.Y.

Meetings

72d Semiannual Convention of the SMPTE, Oct. 6-10, Hotel Statler, Washington, D. C.

Other Societies

National Electronics Conference, Annual Meeting, Sept. 29–Oct. 1, Sherman Hotel, Chicago, Ill.

Optical Society of America, Oct. 9–11, Hotel Statler, Boston, Mass.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 13–17, New Orleans, La.

American Physical Society, Oct. 17–18, Cornell University, Ithaca, New York

Acoustical Society of America, Nov. 13–15, Balboa Park, San Diego, Calif.

American Standards Association, Annual Meeting, Nov. 19, Waldorf-Astoria, New York

American Physical Society, Nov. 28–29, Washington University, St. Louis, Mo.

American Institute of Chemical Engineers, Annual Meeting, Dec. 7–10, Cleveland, Ohio

Institute of Radio Engineers Conference and Electronics Show, 5th Annual Southwestern Conference and Show, Feb. 5–7, San Antonio, Texas

Basic Principles of the Three-Dimensional Film

By RAYMOND SPOTTISWOODE, N. L. SPOTTISWOODE and CHARLES SMITH

Professional three-dimensional (3-D) film productions cannot be satisfactorily undertaken without a comprehensive theory of the transmission of an image in space from scene to screen. In Part I the outlines of such a theory are laid down, and the elements of a standard set of concepts and nomenclature put forward. Part II draws an example from a recent film, *The Black Swan*, to show how the stereotechnician computes a sequence of shots in the desired space relationship, and how simple graphical techniques may be employed to plot such relationships. From these graphs may be determined the magnitude of any postcorrections required to alter the continuity in space, to adjust the film to screens of widely differing size or to eliminate certain camera errors. Part III forms a critique of existing camera procedures, including those based on the supposed identity between human vision and the viewing of the space image. Part IV sums up the differences of technique between the flat film and the 3-D film.

Up to now the production of three-dimensional (3-D) films has been sporadic — scattered all over the world and separated by long intervals of time. Most of the practical information available was to be found in papers by the American pioneer, J. A. Norling, which were read before the Society;[1] but these dated from before World War II and applied to films of rather limited scope.

A contribution submitted July 21, 1952, by Raymond Spottiswoode, N. L. Spottiswoode and Charles Smith, Stereo Techniques, Ltd., 36, Soho Square, London, W.1., England. This article is an adaptation of part of the forthcoming book, *The Theory of Stereoscopic Transmission.*[4]

More recently in England, the Festival of Britain afforded an opportunity to produce a varied program of stereoscopic films; these too have been described in outline in the *Journal.*[2,3] Production did not stop at this point, however, for a further series of films was initiated for commercial distribution starting in the early summer of 1952. Both these programs were based on the same body of technical principles; both were the work of the same groups, one in Canada for the animation films, the other in Britain for the studio and actuality films. By the completion of the second program, therefore, with an output of about a dozen films, much production experience had been

gained and knowledge accumulated on the ways in which audiences see and react to this new kind of film. The present paper is an attempt to summarize a part of this knowledge in the hope that it may be of value to American producers who are experimenting in the 3-D medium. To make the theoretical part of the treatment more concrete, we relate it in an extended example to a particular film completed a few months ago.

A 3-D Ballet Film

The presentation of our Festival program at the Telecinema drew many requests for a stereoscopic ballet — a subject notoriously difficult to film satisfactorily in the ordinary way. We therefore decided to produce a ballet film for 1952, even though time did not allow of special choreography to take fullest advantage of the dimension of depth. Our final choice fell on an episode from Tschaikovsky's *Swan Lake*, which made a story complete in itself within the limits of 13 minutes of film, and enabled us to feature two of the star dancers of the Sadlers Wells and Covent Garden companies, Beryl Grey and John Field.

Shooting was to be limited to four days on the studio floor, and this meant careful preplanning of stereoscopic effects in relation to the script. For this purpose it was essential to know how the dancers were to move in relation to the movements of the camera, which was to be mounted on a crane in the interests of complete fluidity. There was, however, a formidable problem to contend with which has no counterpart in the making of ordinary films: namely, to control the position in space in the ultimate movie theater of each scene occurring in space before the camera. The continuity might demand a smooth spatial transition between one shot and the next; or there might have to be an abrupt impact of something presented much nearer to the eye or much farther away than the audience would expect. Examples of both types of "continuity in space" abound in this film. Again, from shot to shot it would be necessary to adjust the camera to the precise range of distances in the scene before it; and if any errors occurred at this stage, it must be possible to determine and correct them by optical printing. Finally, in the interests of strain-free viewing, it was essential to be able to take into account all those factors which affect the fusion of the images, and whose neglect in the past has often led to eye fatigue and has tended to give 3-D films a bad name among the public.

There is no way of achieving this assured control over the image throughout its progress to the movie theater except by having at one's command a complete knowledge of the stereo transmission system between camera and spectator. Fortunately, long before the shooting of *The Black Swan* was attempted, such a transmission theory had been worked out, and a full account of it will shortly be available to American readers.[4] Nonetheless, some attempt must be made here to indicate the nature of the problems and the lines along which they can be solved.

PART I: THEORY

As is well known, all commercial stereoscopic film systems of today are of a type which may be called *plano-stereoscopic:* that is, the constituent optical images from which the depth image is formed by binocular fusion are projected on a surface, the screen. In large-screen projection, these optical images are superimposed, and must be sorted out by each spectator with the aid of individual viewing devices, which are normally of polarizing material. It is thus necessary to start with an analysis of the way the spectator sees the picture in space, after

which we can work back through the projection and production processes to the camera which is to be controlled on the studio floor.

Psychological Viewing Factors

In the spectator's mind two altogether different sets of impulses are at work. The binocular faculty attempts to place objects in space by methods which are still imperfectly understood in their entirety, but which may for simplicity be likened to the working of a rangefinder. At the same time, other departments of the mind are busy observing all sorts of other clues to depth and position in space. There may well arise conditions when these two sets of data will conflict, leading to an ambiguity in the image which different people will resolve differently — much as two people may sit down before a Picasso canvas in the Museum of Modern Art and come to wholly different conclusions as to what it is all about. Even more serious difficulties will arise if the conflict is so fundamental that the spectator cannot bring himself to believe in the stereoscopic data. A scene may be brought forward to a certain plane in space, but will not in fact appear to be there because the audience cannot accept the fact that a dining room table or a ballet dancer is poised in space over the front rows of the stalls. This effect has been known for many years, and is well analyzed in a classic paper by Professor J. T. Rule.[5]

The planning of our stereoscopic films does of course take account of these and many other psychological factors; and we hope, if interest in the 3-D film continues active, to discuss in a later paper a number of new ways of bridging the remaining gap between audience and space film. In the present paper we shall confine ourselves to considering the physical elements in the stereoscopic transmission system, since these have been the subject of much fruitless debate, which it is time to try and replace with an agreed nomenclature and method of mathematical approach.

The Mechanics of Viewing

The elements of a plano-stereoscopic projection system, with image separation at the spectators' eyes, are sketched in Fig. 1. A generalized spectator is shown, placed at a distance, V, from the screen, onto which have been thrown left- and right-eye images. It is convenient to consider these images as consisting of a multitude of separate points, much as is often done in discussions of film resolving power. In general, to each point on the left-eye image there will be some corresponding point in the right-eye image, both image points having the characteristic that they represent the same object point in the original scene.* These image points are sometimes called *homologous points*, and they are represented in Fig. 1 by L and R.†

The eyes are shown as having a separation, t, this letter also being used in our nomenclature to denote the lateral separation of optical axes, suitable subscripts being used to distinguish the camera and projector. Through their selecting viewers, the eyes regard separately the left and right members of each pair of homologous points on the screen, whose horizontal separation is known as *parallax*. Parallaxes are always denoted by

* Note that the original object may be imaginary, as in 3-D abstract and cartoon films.

† It is noteworthy that, in a projection system such as we are discussing, the eyes are able to prompt the mind without any additional clues as to which pairs of points are to be considered homologous; occasional errors — as in the fusion of wire mesh and wallpaper patterns — occur also in binocular vision and are of negligible importance in practice. On the other hand, some types of integral screen, which dispense with viewers for seeing 3-D films, require the transmission of information as to which points are homologous, and are therefore "information-consuming" and wasteful.

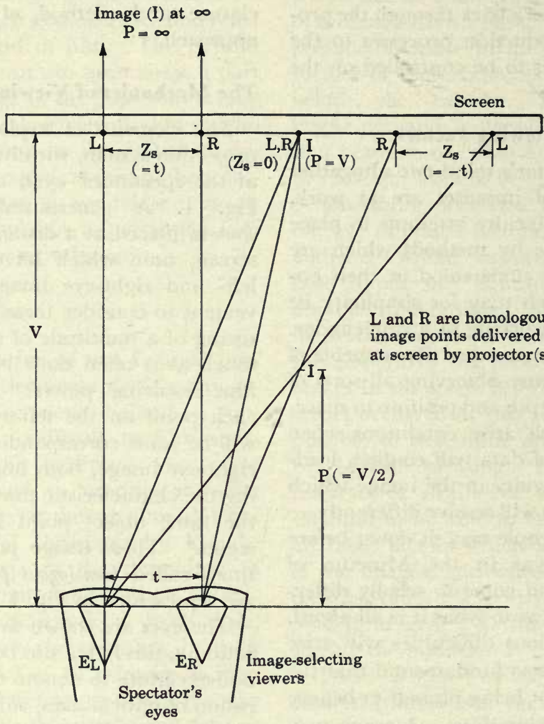


Fig. 1. Construction of a space image point (I) from optical image points, L and R. A spectator's eyes, E_L, E_R, having a lateral separation, t, are equipped with selecting viewers and regard, respectively, left and right corresponding image points, L and R. These are separated on the screen by a parallax, z_s, which may be positive or negative. The spectator, distant V from the screen, will see the fused image point, I, at the intersection of the rays from E_L to L, and E_R to R. His distance from I is denoted by P.

the letter z, a subscript being added to distinguish the kind of parallax referred to. Thus a screen parallax is z_s, a parallax on the projected film z_p, a parallax introduced by displacement in the optical printer z_d, and a parallax originating in the camera z_c.

Three special cases are shown in Fig. 1; (a) that in which $z_s = t$, for which rays of light are reflected parallel from the screen, so that the image point is placed at infinity; (b) that in which $z_s = 0$, in which the point is imaged in the plane of the screen (whence it follows that a normal flat film is merely a special case of the 3-D film, that in which $z_s = 0$ for all image points); and (c) that in which $z_s = -t$, and the image, as may be seen from simple geometry, is halfway out to the spectator.

From previous theoretical discussion, the impression has got around that stereoscopic projection is extremely complicated, requiring special and often vari-

able alignment of the projectors, and an analysis of keystone distortion, optimum lens focal length, and so forth. Projectors, however, are much better regarded as fixed mechanisms, which cannot be swiveled or otherwise adjusted from shot to shot. Furthermore, image distortion arising from projection is no more objectionable in a 3-D than in a flat film, and can safely be relegated to the background as a second-order problem,* provided that no additional distortion is caused by beam-splitting or other methods.

Hence it is only necessary to agree on the parallax at the screen between the left-eye image, regarded as a whole, and the right-eye image regarded as a whole. The alignment which we have adopted is that which differs least from the standard alignment of projectors for flat films, namely, one in which the image centerlines are superimposed. This can be succinctly expressed as $z_{CL} = 0$. Some consequences of altering the value of z_{CL} are discussed later in this paper.

With t, the spectator's eye separation, substantially constant at 2.5 in., and with z_{CL} assumed equal to zero, only two projection factors need to be considered: V, the spectator's distance from the screen, and M, the linear magnification which the image undergoes from film to screen.

The Nearness Factor

Referring again to Fig. 1, we can now advance to the first useful generalized concept, which appears not to have been remarked on before, though it is essential to any clear discussion of the production of 3-D films. It may be stated quite generally that, *for any pair of optical image points, the ratio of the spectator's viewing distance* (V) *from the screen to his distance* (P) *from the fused image point is a constant, no matter whereabouts in the theater he may be sitting.*

This ratio we call the *nearness factor* (N) of the image point, and we may therefore write,

$$\frac{V}{P} = N \tag{1}$$

It is apparent that,

if $P = \infty$, $N = 0$ (image at infinity),

if $P = V$, $N = 1$ (image at the screen plane),

if $P = \frac{V}{2}$, $N = 2$ (image halfway out to spectator), and so on.

We can therefore state unambiguously for the first time where we wish a certain object in a studio set or on location to appear in space to the spectator in the movie theater.* If the director says that he wishes an actor seated at a table to be represented at $N = 0.5$, while another's hand, outstretched toward the audience, is to be at $N = 4$, the stereotechnician knows at once that each spectator is to see the first actor at twice the viewing distance to the screen, whereas the other's hand must come out from the screen three-quarters of the way toward him. The concept of the nearness factor is easily grasped, even by studio personnel to whom the rest of the stereo shooting procedure remains something of a mys-

* Projector separation, t_p, inevitably produces some second-order distortion due to keystoning. This is analyzed fully in Reference 4, together with some attendant anomalies of vision which help to rectify the shape of the image.

* In 1856, Sir David Brewster, writing about the wire mesh and wallpaper phenomena mentioned above, gave numerical data from which the constancy of N with change of viewing distance can be correctly inferred.[6] But he failed to generalize the concept of the nearness factor, no doubt because of his preoccupation with the problems of individual viewing. (It must be remembered that, prior to the invention of the incandescent lamp, only very rudimentary means were available for projection to large audiences.) Nonetheless, Brewster was far ahead of his time, and his book is even now worth reading.

tery; but it affords the connection of ideas most necessary to establish between director and stereotechnician.

Object Distances and Image Distances

Next we must see how the position of the camera in front of the scene is related to the image of that scene in front of the spectator. Denoting by d_n the distance from the camera to a given object point, there will be a corresponding image point seen by a spectator in the theater as having a nearness factor, N_n. Specifically, we may refer to an image point at N_0 (infinity) deriving from an object point at d_0, an image point at N_1 deriving from a point at d_1, and so on.

Now if we were to graph the distance of object points d_0, d_1, d_2 . . . against the actual distance, P, of the corresponding image points from the spectator, it must not be supposed that the result would necessarily be a straight line. This represents an important but entirely special type of stereoscopic transmission; that is to say, one in which the rendering of distance is a linear function. We shall meet this again later on, but it is worth observing here that linear transmission does not of itself produce an *orthostereoscopic* image, or one which is geometrically congruent with the original scene. There may be a multiplying factor either greater or less than unity by which a given length is stretched or shrunk, though of course uniformly throughout the scene.

A New Unit: The Rho

We now come to the problem of relating d_0, d_1, d_2 . . . in the scene to N_0, N_1, N_2 . . . in the theater. Here another important step forward has been taken in the simplification of stereo calculations by introducing a new unit of distance. It can be shown that *if a reciprocal distance unit is employed, equal numbers of depth units in the scene will always correspond with equal changes of nearness factor in the cinema, no matter whether the transmission system is linear or nonlinear.*

Thus at one stroke a mass of difficult computation is done away with, and depth ranges in the scene can be manipulated by simple arithmetical addition and subtraction.

The new distance unit has been named a *rho* ("reciprocal" denoted by the Greek letter ρ), and to bring it to a convenient size it is defined as the reciprocal of the distance in inches multiplied by an arbitrary constant, the ρ constant (K), which has been set at 6,000. Thus we may write

$$\text{distance in } \rho = \frac{6{,}000^*}{\text{distance in in.}} \tag{2}$$

This is equivalent to 500 divided by distance in feet, and the units of course decrease with increasing distance, and vice versa, as is shown in Table I.

Table I

Distance	ρ	Distance	ρ
100 ft	5	6 ft	83
50	10	5	100
33	15	4 ft 6 in.	111
25	20	4 2	120
20	25	4	125
10	50	3 4	150
7	71	3	167

Whereas distances in linear units are expressed as d_0, d_1, d_2 . . ., the corresponding ρ distances are designated D_0, D_1, D_2 . . . . All measurements on the set and on location are made with a tape graduated in ρ on one side and in feet and inches on the other, for focusing. (In passing, it is worth noting that if lens-focus scales were engraved in ρ, they would be calibrated with equal separations for equal ρ differences, in place of the present unequally divided scales. Furthermore, depth of focus tables would need only one entry under each focal

* Because of the superior convenience of a decimal system of linear units, we have recently converted to the metric system. 1 metric ρ = 10,000/distance in cm.

length and aperture setting, instead of a multitude of entries relating to all possible focus distances. But to gain these worth-while advantages, camera assistants would have to train their minds to udge distances nonlinearly, which would no doubt prove difficult!)

In order to indicate how the general equation is derived, which connects the distance of objects in the scene with the distance of their corresponding images in the cinema from the spectator, it is necessary to return for a moment to the cinema and re-examine the parallaxes on the screen (z_s). Referring again to Fig. 1, and adopting the sign convention that uncrossed parallaxes are positive and crossed parallaxes negative, we can see at once that

when $z_s = t$, $P = V/0$, i.e., image at N_0 (infinity)
$z_s = 0$, $P = V/1$, i.e., image at N_1 (plane of screen)
$z_s = -t$, $P = V/2$, i.e., image at N_2 (halfway out)
$z_s = -2t$, $P = V/3$, i.e., image at N_3 ($\frac{2}{3}$ of way out)
$z_s = -3t$, $P = V/4$, i.e., image at N_4 ($\frac{3}{4}$ of way out), and so on.

Note: In our standard terminology, the letter t always represents the lateral distance between two optical axes, t itself denoting the separation of the human eyes (here assumed throughout as 2.5 in.), t_c the separation of the camera optical axes, t_p that of the projector optical axes, etc.

In other words, equal negative increments of parallax produce equal increases in N value. Moreover, these parallaxes are absolute; that is to say, they derive only from factors which are constant for any observer sitting in a given position in the cinema. They are irrespective of the size of the screen. But the corresponding parallaxes on the projected film, z_p, are related to the screen parallaxes, z_s, by an optical magnification, M, which will be greater or smaller according as the screen is wider or less wide. Stated the other way round, a parallax of given magnitude on film will produce a greater or lesser stereoscopic depth according as the screen is larger or smaller. This important influence of screen size was first clearly stated, and its effects remarked on, by Professor Rule in the paper already cited.

Depth Content in the Theater

At this stage it will help to introduce another concept, that of the *depth content* of the film in the cinema; in other words, the range of depth in space which the image occupies. Let us assume a difference in nearness factor of 2 between the front and rear planes of the image, which we shall express as $^{\Delta}N_2$. Normally the range of N values would be from N_0 (infinity) to N_2, but from the point of view of the parallax analysis which follows, the position of the N range in space is immaterial. For example, $^{\Delta}N_2$ might correspond to the range N_1–N_3, as in the recent McLaren cartoon film, *Twirligig.*

Now it is apparent from what has been said that

$$z_p = \frac{z_s}{M} \tag{3}$$

Since a change in N value of 1 results from a change of screen parallax of t, a depth content of $^{\Delta}N_1$ corresponds to a parallax on the projected film of $2.5/M$ in., a depth content of $^{\Delta}N_2$ to $5/M$ in., and so on.

Magnitude of Film Parallaxes

In order to give a more concrete idea of the magnitude of the actual film parallaxes when shooting for screens of normal commercial size, it may be helpful to deviate for a moment from the main course of the argument. Table II has been prepared to show the total span of film parallaxes available (in mils) for films

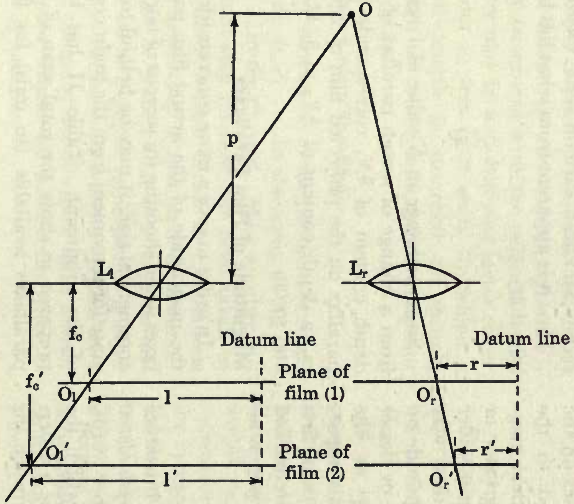


Fig. 2a. Relation between camera film parallax (z_c) and lens focal length (f_c). Object point O, distant p from camera, is imaged on film at O_l, O_r, through lenses L_l, L_r, of focal length f_c; and at O_l', O_r', with lenses of longer focal length f_c' (film plane shown schematically as being moved back). Parallax $(l - r)$ measured from identical datum lines (e.g., guided edge or perforations).

When $f_c' > f_c$, $l' - r' > l - r$
When $f_c' < f_c$, $l' - r' < l - r$

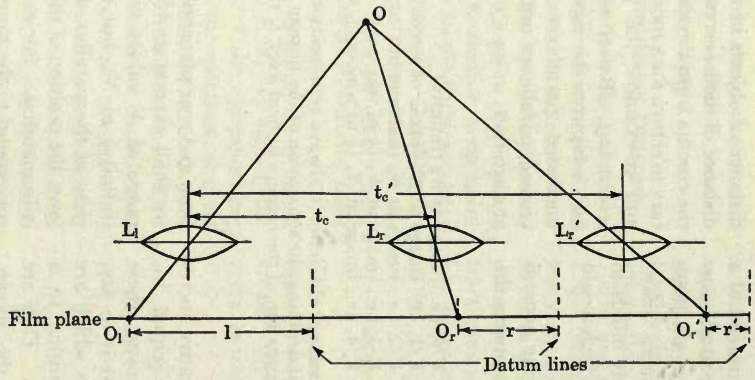


Fig. 2b. Relation between camera film parallax (z_c) and lens separation (t_c). Object point O is imaged on film at O_l, O_r, through lenses L_l, L_r, having a separation t_c, and through lenses L_l, L_r' having a separation t_c'. (Parallax measured as in Fig. 2a.)

When $t_c > t_c$, $l - r' > l - r$
When $t_c' < t_c$, $l - r' < l - r$

Table II

Magnification (M)*	Screen Width (W)	Total projected film parallax, z_p (mils) for $^{\Delta}N_1$	$^{\Delta}N_2$	$^{\Delta}N_3$
200	13 ft 9 in.	12.5	25.0	37.5
250	17 2	10.0	20.0	30.0
300	20 8	8.3	16.7	25.0
350	24 1	7.1	14.3	21.4
400	27 6	6.25	12.5	18.75

* Based on the standard 35-mm projector aperture width, 0.825 in.

Table III

M	Minimum values of z_p (mils) for $\delta N = 0.1$
200	1.25
250	1.00
300	0.83
350	0.71
400	0.63

Note: The bracketed range comprises approximately 67% of existing motion picture theaters, as revealed in the recent SMPTE survey.[7]

employing depth contents of $^{\Delta}N_1$, $^{\Delta}N_2$ and $^{\Delta}N_3$. The $^{\Delta}N_1$ column is of interest merely because there remain some conservative spirits in the 3-D film field who think that no action should take place in front of the screen plane.

In realizing a given depth content in the cinema, there is however another factor to consider. The representation of a given depth space may be imagined as built up of an infinite number of infinitely thin planes. Were this achievable, we might say that the *stereoscopic resolving power* was infinite, for the system would have an infinite capacity to discriminate depth. In actual practice, however, these planes will be replaced by more or less shallow zones, within each of which a position in depth will not be accurately reproducible. The depth of the zones will therefore be a measure of the stereoscopic resolving power of the system. These zonal depths may conveniently be denoted by the change in nearness factor, δN, which they represent, and we accordingly employ the concept of δN to clarify discussions of resolving power, without suggesting that this will necessarily be the unit finally accepted.*

Assume, then, that any volume of space denoted by $^{\Delta}N_1$ is to be representable in 10 zones of depth; in other words, $\delta N = 0.1$. We can then tabulate the minimum film parallaxes which it will be necessary to have recorded reproducibly on the projected film — that is, after taking into account all possible random parallactic errors in previous stages of the transmission system.

Table III shows that, for screens found in the majority of commercial theaters, the minimum reproducible film parallaxes needed to achieve a depth resolving power of 0.1 do not much exceed the dimensional tolerances of the film itself, let alone allowing for shrinkages which may occur at intermediate stages in commercial laboratory practice, or for mechanical errors in the stereoscopic adjustments of the camera. The need for extreme precision is still further emphasized by the fact that $\delta N = 0.1$ is equivalent to only 20 separable zones in space for a normal 3-D film having a depth content of $^{\Delta}N_2$.

The General Equation

Reverting to our main theme, it will be evident that the greater the magnification, M, the greater the screen parallax to be derived from a given film parallax. Turning to the camera, it can be seen from Fig. 2 that an object point at a given distance produces a greater film parallax, (a) the longer is the focal length, f_c, of the camera lens(es), and (b) the greater is the lateral separation, t_c, of the lenses or optical systems. Thus an increase in these three factors, M, f_c

* Experiments are being undertaken with trained observers to determine whether δN, δP or perhaps some other concept corresponds best with the subjective impression of depth resolution.

and t_c, increases the final parallax on the screen, whose absolute magnitude determines the N value of the image point corresponding to the original object point, O. In fact the product Mf_ct_c is combined into what is called the *C factor* in our general equation.

This equation, which will be stated but not derived here, expresses the distance, P, of a fused image point from the spectator in terms of the distance, p, from the camera of the original object point, together with the other variables of the transmission system.

$$P = \frac{Ap}{C - Bp} \qquad (4)$$

Thus, besides M, f_c, t_c and p, which we have already mentioned, there is an A factor and a B factor. The *A factor*, Vt, is a function of the spectator and his viewing distance from the screen, as may be seen from Fig. 1. The *B factor* denotes an important transmission concept, which is governed by the convergence of the camera optical axes (or its preferable equivalent, inward lateral displacement of the lenses relative to the films).

The B factor can be related to a camera convergence half-angle, φ, and a projector convergence half-angle, θ, as follows, taking account of the fact that an optical printing displacement, z_d, may have been introduced between the camera film and the projected film:

$$B = t_p - t + 2M(f_c \tan \varphi - f_p \tan \theta + z_d) \qquad (5)$$

If lens displacement is employed instead of toe-in in the camera, h, and projector, H, we may write instead,

$$B = t_p - t + 2M(h - H + z_d) \qquad (5a)$$

As a transmission factor, B may be very much more simply defined. Let ${}^\infty z_s$ denote the screen parallax of a point which was at infinity in the scene, i.e. at D_0. Then

$$B = {}^\infty z_s - t \qquad (6)$$

Expressed in words, B is the excess of screen parallax of a point originally at infinity over the separation of the human eyes.

B+, B = 0 and B− Transmission

Three important cases now arise: that in which B is positive, that in which it is zero, and that in which it is negative. The discussion of the three types of stereoscopic transmission system will help to clear up the vexed question of camera convergence, a subject on which much ink has been spilt in the effort to establish as fundamental relationships what have been only rough-and-ready rules. Several of these are now being purveyed by inventors in France, Germany and Holland, but on investigation they are found to be merely crude approximations, the errors in which may be masked by the fact that they have been applied only to films projected on very small screens.

Figure 3 shows in graphical form the principal characteristics of $B+$, $B = 0$ and $B-$ transmission systems. It is to be noticed that both axes are scaled in a reciprocal type of unit, the x-axis in terms of D, and the y-axis in terms of N. Hence the origin represents infinity on both axes. From Eq. (6) it will be seen that when $B = 0$, ${}^\infty z_s = t$. When, as here, the screen parallax of a point equals the eye separation, t, rays reaching the eyes will be parallel, as they are when reflected from points at infinity. In other words, infinity in the scene (see definition of ${}^\infty z_s$) appears at infinity in the cinema. Thus a $B = 0$ shot must be represented in Fig. 3 by a line passing through the origin, and no other type of shot can be so represented. Referring again to Eq. (6), if ${}^\infty z_s$ exceeds t, it must be that some point short of infinity in the scene produces on the screen a parallax equal to t (because a point *at* infinity produces a parallax greater than t). Thus, when B is positive, a point nearer than infinity in the scene will correspond on the screen with a point which tends to appear at infinity. On the other hand, if ${}^\infty z_s$ falls short of t, so that B is negative, it must

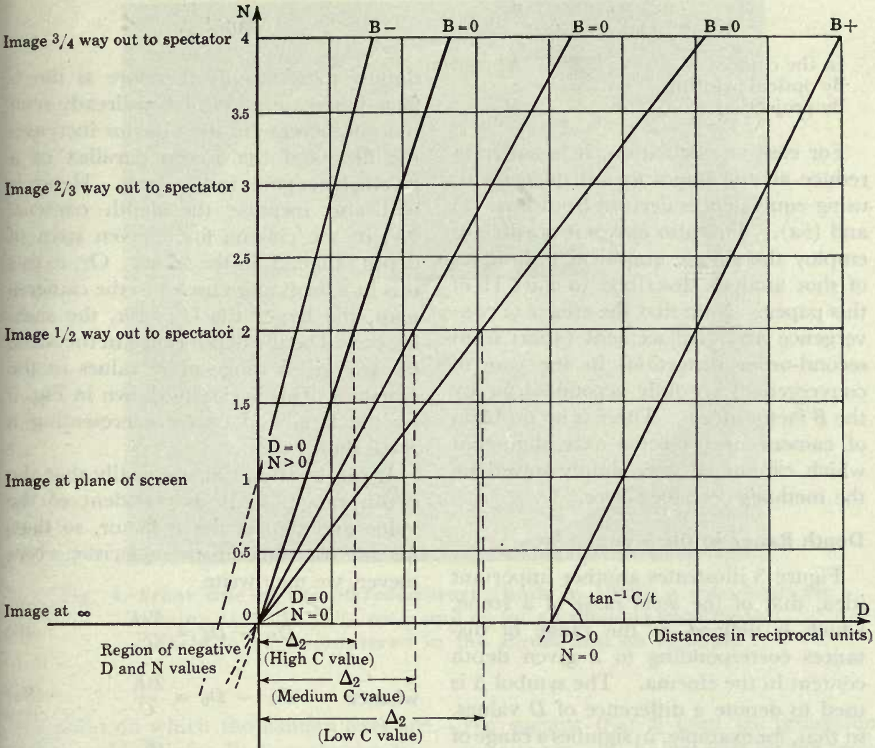


Fig. 3. The three types of stereoscopic transmission system: $B+$, $B = 0$ and $B-$.

be that a point situated at infinity in the scene will appear at some nearer distance in the cinema. All examples of stereoscopic transmission (in other words, all instances of 3-D recording and reproduction) must fall into one of these three classes, whose main characteristics may be exhibited thus:

Class	*Name*	*Characteristic*
$B = 0$	Ortho-infinite	Linear; infinity points correctly represented.
$B+$	Hyper-infinite	Nonlinear; objects short of infinity represented at infinity.
$B-$	Hypo-infinite	Nonlinear; objects at infinity represented closer than infinity; cardboarding.

In the example of a $B-$ system shown in Fig. 3, it will be noticed that infinity (i.e. $D = 0$) will appear on the screen plane, that is, at N_1. This will occur, for example, if a shot of distant objects is taken with the camera axes parallel ($\varphi = 0$), and projected with the projector axes toed-in so that the parallax of the aperture centerlines is zero ($z_{CL} = 0$). This frequently happens with amateur projection of stereoscopic stills and movies.

In short, the B factor can be varied at three stages in the production process, either angularly or by displacement, as follows:

	By toe-in	By displacement
In the camera	φ	h
By optical printing	—	z_d
By projection	θ	H

For ease of calculation, it is better to reduce all the stages to a displacement, using equivalences derived from Eqs. (5) and (5a). This also makes it possible to employ the simple graphical techniques of shot analysis described in Part II of this paper. Note that the effects of convergence and displacement (apart from second-order distortions in the case of convergence) are fully accounted for by the B factor alone. There is no problem of camera or projector axis alignment which cannot be very simply solved by the methods described here.

Depth Range in the Scene

Figure 3 illustrates another important idea, that of the *depth range* of a scene, which is defined as the range of distances corresponding to a given depth content in the cinema. The symbol Δ is used to denote a difference of D values, so that, for example, Δ_1 signifies a range of reciprocal distances which will produce a depth content of ${}^{\Delta}N_1$ in the cinema under given transmission conditions. Δ_1 may of course designate $D_1 - D_0$ or $D_2 - D_1$, and so on, as with its equivalent in the cinema, ${}^{\Delta}N_1$. It will be noticed from Fig. 3 that the depth range may be obtained from the depth content, or vice versa, by simple reflection through the appropriate characteristic curve, which will always be a straight line, no matter whether the transmission is linear or nonlinear.

These curves are based on the fundamental equation connecting reciprocal distances in the scene with nearness factors in the cinema. It is derived from Eq. (4) and can conveniently be written,

$$N = \frac{C}{t}\cdot D - \frac{B}{t} \tag{7}$$

Hence the characteristic curves of Fig. 3 make an angle with the x-axis equal to

$$\tan^{-1}\frac{C}{t},$$

sloping more steeply therefore as the C factor increases. We have already seen that an increase in the C factor increases the film and the screen parallax of a given object point in the scene. Hence it will also increase the depth content, ${}^{\Delta}N$, in the cinema for a given span of depth range, Δ, in the scene. Or, to put this in a form more useful to the cameraman, the larger the C factor, the shallower will be the depth range in the scene for any given range of N values in the cinema. This is clearly shown in Fig. 3 by the family of curves representing a $B=0$ shot.

It can be shown algebraically that the depth range, Δ, is independent of the value and sign of the B factor, so that, for any transmission characteristic whatsoever, we may write

$$D_N - D_0 = \frac{NtK}{C} \tag{8}$$

whence

$$D_2 - D_0 = \frac{2tK}{C} \tag{8a}$$

and

$$D_1 - D_0 = \frac{tK}{C} \tag{8b}$$

where D is expressed in ρ and K is the ρ constant, 6,000.

Finally, combining Eqs. (8a) and (8b), we may write

$$D_1 = \frac{D_2 + D_0}{2} \tag{8c}$$

This furnishes us with the necessary relationships between all the significant distances in the scene. It remains only to show how D_1 determines the convergence or effective convergence of the camera axes.

If the camera axes are toed-in on a point at a certain distance, the film parallax, z_c, of this point will be zero. If, then, the images are projected on a screen with $z_{CL} = 0$, the point will appear on the plane of the screen, i.e. at N_1. Hence the original distance of the point was D_1. In other words, when $z_{CL} = 0$,

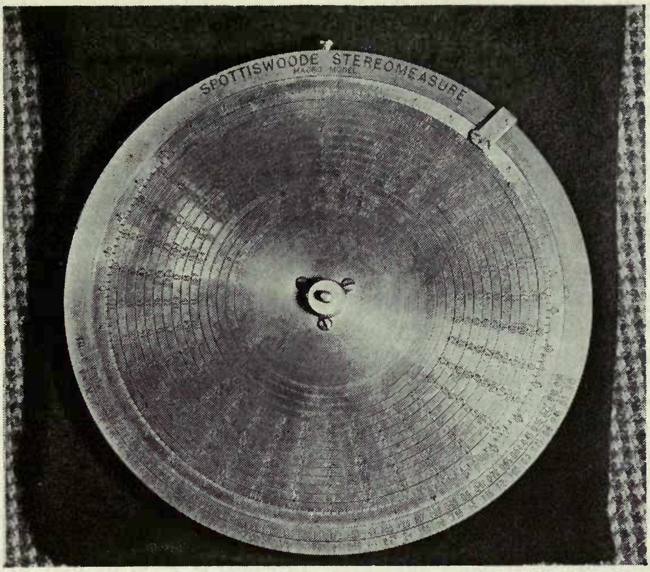


Fig. 4. Front side of the Stereomeasure (built in 1950), a calculator for relating D, Δ, M, f_c, t_c, cot φ and m_d for all shooting conditions likely to be encountered in the studio and on location.

the point on which the camera axes are converged is distant D_1 from the camera.

The half-angle of convergence being denoted by φ, it is evident that

$$\varphi = \tan^{-1} \frac{t_c D_1}{2K} \tag{9}$$

where t_c is in inches, and D_1 in ρ. In terms of d_1, the distance in inches from the camera to the point of convergence, we may write

$$\varphi = \tan^{-1} \frac{t_c}{2d_1} \tag{9a}$$

If, which is preferable, each optical system is laterally displaced inward through a distance, h, in relation to the film, we may write instead,

$$h = \frac{f_c t_c D_1}{2K} \tag{10}$$

Or, expressed in terms of d_1,

$$h = \frac{f_c t_c}{2d_1} \tag{10a}$$

We suggest that h (and its projection counterpart, H) be denoted by the term *edge-in* to differentiate it from physical convergence of camera and projector axes which is often conveniently described as *toe-in.*

The Stereomeasure

With the aid of the reciprocal distance system and Eq. (8) and its variants, an experienced stereotechnician can make all the necessary depth range and depth content calculations in his head, finally obtaining the values of φ or h from simple tables. However, as an aid to memory, these relationships and others have been embodied in a calculator, the Stereomeasure, which was designed and built in 1950 and has since been used for every one of our productions. One side of this calculator is shown in Fig. 4. It gives immediate numerical answers to all problems of how the camera should be set up to produce the effect in space de-

manded by the director, whether this be intended to soothe or startle, and whether the continuity from shot to shot be a matching or a deliberate mismatching of planes. Recently, with the aid of metric units and other simplifications, it has proved possible to design a much more compact version of the Stereomeasure which contains the same information but lends itself to quantity production.

So far we have been concerned with the space relationships obtaining between a scene existing in real space and the same scene as reconstructed in stereoscopic space by a binocular spectator sitting in the motion picture theater; and we have seen how these two quite different types of space can be related to one another by adopting new systems of measurement and comparison.

Stereoscopic Magnification

The next step is to examine how the size and shape of objects are affected by their stereoscopic transmission and reproduction. It is well known that a monocular image is essentially ambiguous, for the data it contains can (in the absence of other evidence) be construed by the spectator's mind as presenting a small object at a near distance or a much larger object farther away. By contrast, a binocular image — on the basis of the stereoscopic data it contains — is entirely unambiguous; it is determinate in size, shape and position. But these characteristics do not necessarily conform with those of the object represented; its image in space may be larger or smaller, widened or elongated, nearer or farther away. These distortions are certain to arise when presenting pictures on large screens; but whether they are objectionable or not depends on a great many factors, some stereoscopic, some extra-stereoscopic, and some psychological, which will vary greatly from one spectator to another. Nonetheless, it is important to be able to determine mathematically what distortions the image has undergone, and this must form an integral part of the whole transmission theory, just as much as an analysis of waveform distortion forms part of the theory of electronic amplification.

Considering the stereo image of an object in the real world, we may call the ratio of the stereoscopic image size to the real object size the *stereoscopic magnification*, which may of course be greater or less than unity. It can be shown that the depth of objects may undergo one type of magnification (called depth magnification, m_d), while the height and width of objects — dimensions between which a plano-stereoscopic transmission system does not discriminate — undergo another type of magnification, called width magnification, m_w.

Stereoscopic magnification varies, among other things, with the size and sign of the B factor. In the general case, in which $B \neq 0$, we may write, for any given plane in the image having a nearness factor, N,

$$m_d = \frac{Vt}{Mf_ct_c}\left(\frac{B}{Nt} + 1\right)^2 \qquad (11)$$

When $B = 0$, the expression in brackets equals unity, and the equation reduces to

$$m_d = \frac{Vt}{Mf_ct_c} = \frac{A}{C} \qquad (11a)$$

It can also be shown that, in the same general case in which $B \neq 0$, the width magnification for an image plane having a nearness factor, N, is given by

$$m_w = \frac{t}{t_c}\left(\frac{B}{Nt} + 1\right) \qquad (12)$$

When $B = 0$, this reduces to

$$m_w = \frac{t}{t_c} \qquad (12a)$$

Finally, since it is often the shape of objects which is more important to their acceptability than their absolute magnification along any dimension, it is helpful to introduce the concept of the *shape ratio*, μ. Then

$$\mu = \frac{m_d}{m_w} = \frac{V}{Mf_c}\left(\frac{B}{Nt} + 1\right) \quad (13)$$

Since Eqs. (11)–(13) involve the B factor, it is convenient to have an expression by which this factor can be easily reckoned when working out numerical examples. It is assumed that C and D_1 are known, as they will be when shooting conditions have been established. Then,

$$B = \frac{CD_1}{6{,}000} - t \quad (14)$$

where f_c, t_c and t are measured in inches, and D_1 in ρ. If d_1 (in in.) is employed in place of D_1, this expression becomes,

$$B = \frac{C}{d_1} - t \quad (14a)$$

The Orthostereoscopic Condition

This is the condition of perfect image reproduction — i.e. that in which the image as a whole is geometrically congruent with the scene it represents. So many inventors have claimed a system which produces a distortion-free image that it is worth investigating just what orthostereoscopy entails. For linear reproduction it is necessary to have $B = 0$, and for geometrical congruence $m_d = m_w = 1$, so that $\mu = 1$. Substituting $m_w = 1$ in Eq. (12a), we have $t_c = t$. Putting $t_c = t$ and $m_d = 1$ in Eq. (11a), we have $V = Mf_c$. Thus the three conditions for geometrical congruence are:

$$\left.\begin{aligned} B &= 0 \\ t_c &= t \\ V &= Mf_c \end{aligned}\right\} \quad (15)$$

If the focal length of the camera lens and the screen size have been determined, the spectator's viewing distance is fixed. Furthermore, for a normal space film having a depth content of Δ_2, it can be shown that, under orthostereoscopic conditions,

$$D_2 = \frac{12{,}000}{Mf_c} \text{ rhos} \quad (16)$$

when the rear of the scene is at D_0.

For example, if $M = 300$ (i.e. a 20 ft 8 in. screen), and if $f_c = 2$ in., the nearest object to the camera must not be closer than 20ρ, i.e. 25 ft. Thus no shooting system can claim to eliminate distortion which does not comply with all the conditions of Eq. (15); and no system which complies with these conditions can claim to be practical for commercial films, since it would be limited to the taking of long shots. Hence it may safely be asserted (notwithstanding many statements to the contrary), that distortions are inseparable from stereo films — as indeed they are from flat films — and that it is therefore necessary to study their character and incidence.

In Part II of this paper are to be found numerical examples which demonstrate very clearly the type of distortion to which a stereoscopic system is prone, especially when large B values are employed. It is the depth of objects which tends to be most exaggerated, because of the squared term in Eq. (11); as the scene recedes, so it rapidly becomes more elongated. Experience confirms the ill effect caused by very large values of B, but it would appear that objects in the foreground and middle distance are the worst sufferers, perhaps because the eyes normally look downward on them more than on distant objects, so that one is more often reminded of their shape.

Binocular Magnification

There is however another kind of magnification to which the stereoscopic image is subject. Stereoscopic depth magnification is based on the supposition of a slight depth shift, dp, in the object position, which is then compared with the corresponding shift in the image position, dP. In other words,

$$m_d = \frac{dP}{dp},$$

a concept which corresponds to that of a one-eyed spectator with a foot-rule at the camera and in the theater — although, of course, in the theater he would

need two eyes in order to construct the depth image at all. Now if a two-eyed observer were stationed at the camera position, the front plane of a given object in the scene would subtend some angle, ω, at his two eyes, and the back plane of the same object a smaller angle, ω'. If $\omega - \omega'$ were not too small an angle for the eyes to discriminate, the object would appear stereoscopically solid. Now suppose this object to be imaged and transmitted to a theater under given conditions. For a spectator of known position and characteristics, the same object will subtend at its front plane an angle Ω, and at its rear plane an angle, Ω'. The ratio of a small change in the image angle, Ω, to a small change in the object angle, ω, may be called the *binocular magnification*, m_b, and an expression may be found for it which is analogous to those enunciated above in Eqs. (11) and (12).

$$m_b = \frac{d\Omega}{d\omega} = \frac{C}{A} = \frac{Mf_ct_c}{Vt} \qquad (17)$$

Note that m_b is purely a form of depth magnification, having no relation to the width of the image, that it is independent of the value of B, and that (were the two kinds of magnification found to be multiplicative in effect), when $B = 0$, $m_d = 1/m_b$. Their inverse operation has important practical consequences which will be discussed in Part II.

The Complete Theory

This short outline of fundamental principles can of course be developed very much further, and its fuller implications are set out in the work already cited.[4] These shed light on fascinating possibilities of set design which take advantage of the image distortions we have noted, just as the set designer of today makes fullest use of the potentialities of linear perspective. They help to analyze many new techniques in cell and puppet animation. They enable the camera designer to lay down parameters for the construction of professional stereo film cameras. They enable a producer to undertake a complicated studio picture in the confidence that all the problems along the way — titles, optical effects, back projection, stereo windows, and so on — can be surmounted with a full knowledge of what is being done.

PART II: PRACTICE

It may be that a transmission theory such as this, containing as it must many new terms and concepts, will at first seem difficult to grasp, and perhaps too abstract for the practical needs of film makers. Yet just these objections were made when sensitometry was first introduced as a science. It was puzzling to have to think of densities and gammas and toe exposures when a mere twist of a lens diaphragm had previously seemed to suffice; yet today all these and many other terms are so much a matter of instinct that they trip off the technician's tongue with scarcely a second thought. The practice and nomenclature evolved here for the 3-D film have been carefully worked out with the needs of the professional film maker in mind. Very soon he is just as happy with depth ranges and nearness factors as he is with the rest of the science of film, because he can see what these things mean as soon as he starts to make his first stereoscopic movie.

Within the limits of this part of the paper, we shall try to make the reader feel that he is sharing in the production of a section of *The Black Swan*, one of the many films now completed in accordance with this technique. We shall show how the stereoscopic constants are computed, how film parallax is afterwards determined, how camera errors, if present, may be corrected, and how the image in space finally appears to a member of the audience.

The camera on which this film was to be shot consists of the twin assembly de-

Fig. 5. 3-D camera mounted on crane during filming of *The Black Swan.*

picted in Figs. 5 and 6, this being the only equipment presently available in England for double-band 35mm shooting. As can be seen from the nearer view (Fig. 6), two Newman-Sinclair cameras are mounted on a stereoscopic base, shooting into mirrors set at 90° to one another, and having their apex facing the scene.[8] This arrangement provides for convergence by physically toeing the cameras inward, and it enables t_c to be varied from a maximum of 8 in. to a minimum of 1.25 in. (2.5 in. with the 35-mm lenses). To set against this usefully wide variation, the camera has manifold disadvantages, chief of which are that a nonstandard image geometry results from reversal at the mirror surfaces, and that inaccuracies of setting due to faulty construction are so serious and unpredictable that a special optical printing technique has had to be devised to correct them.

The first of the two shots we are going to consider in detail depicts the Male Variation danced by John Field. He finishes with a held pose which, in the stage version of the ballet, enables the audience to applaud. As a counterpart to this, the director, Len Reeve, proposed a stereoscopic curtain effect, making use of a pair of decorative banners which were to be raised before the scene at the end of the first shot, quite close to the audience's eyes. The immediate cut to the next shot would reveal a similar pair of banners at a slightly greater distance, hiding the scene; and as these were raised out of sight, another pair behind them would be revealed, only to rise in favor of a third, and so on until Beryl Grey was discovered at the back of the set beginning her variation.

Always when making a 3-D film the director will search for visual material which will enhance the sense of forward

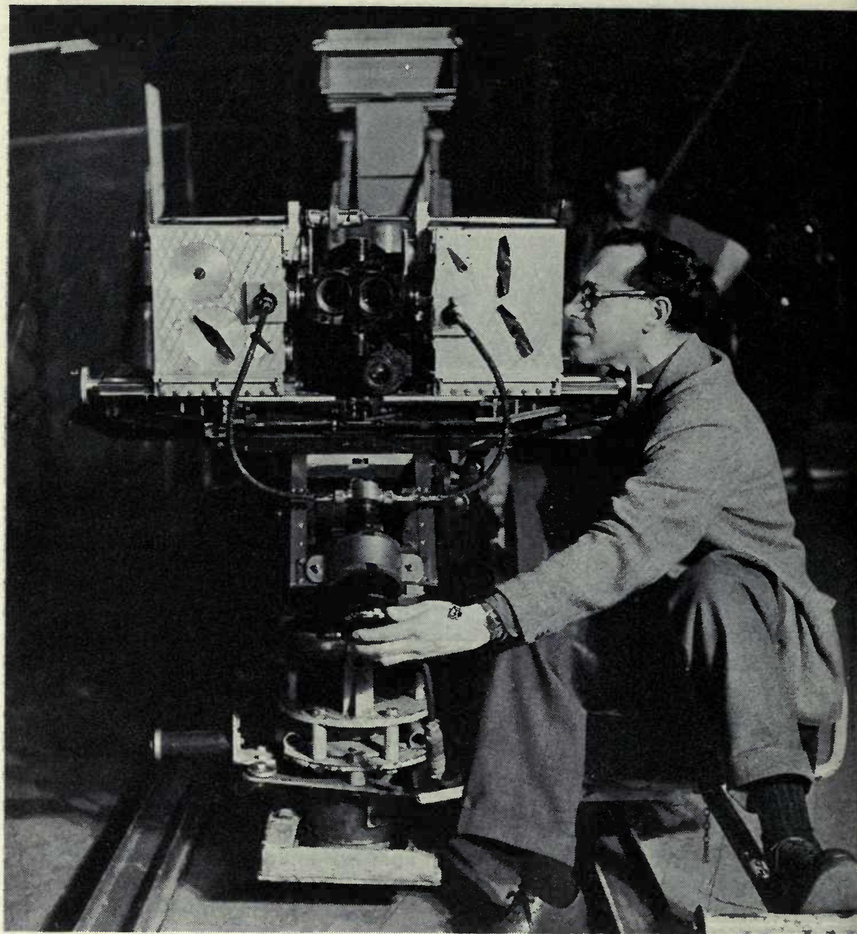


Fig. 6. Front view of 3-D camera showing Newman-Sinclair units in opposed positions and 90° mirrors. Matched lens pairs are available in the normal range from 35mm to 100mm, with coupled focusing; a centrally mounted Mitchell-type viewfinder is used for monitoring.

and backward movement, of nearer and farther away. In unskilled hands this may easily degenerate into a trick, a mere device for showing off the third dimension to the best advantage. But the imaginative director will find that all kinds of new visual ideas will present themselves, which would be ineffective in the ordinary flat film, or which take on a new vitality in the more real world of 3-D. The transition we are discussing proved very successful because the totally unexpected appearance of the banners caused the audience's attention to move rapidly into the extreme foreground, this being followed by the smooth withdrawal of attention to the back of the next scene, the time occupied being sufficient to

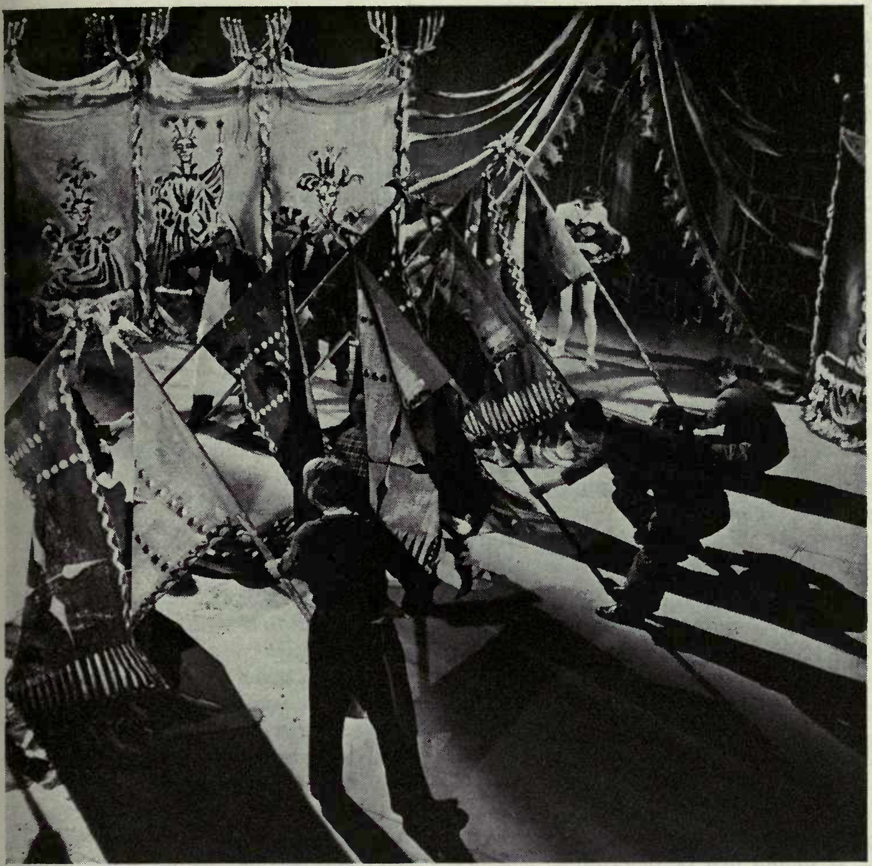


Fig. 7. Slate 15 of *The Black Swan*. Camera out of picture on left, banners raised successively in pairs to reveal Beryl Grey in background.

cover the musical transition and hide the break which was intended for stage applause.

Computing the Stereo Settings

The simple mechanics of this shot are shown in Fig. 7. But how is the stereotechnician on the set to ensure that the director's wishes as to the placing of the scene in space in the ultimate movie theater are precisely carried out? First it is necessary to decide the size of screen for which the film is to be shot, since this will determine M, the one element in the C factor which is not controllable when shooting. If the anticipated variation of screen width is not very great, it is best to set M for the largest screen size, and accept some loss of depth on smaller screens. But if a wide range of screen sizes must be provided for, it is better to find a mean magnification so that the loss on the smallest screen is not too great, while accepting some divergence on infinity points on the large screens unless these are corrected in an optical printing

stage.* *The Black Swan* was to be presented for 22 weeks on a screen only 10 ft 4 in. in width ($M = 150$), and this suggested shooting it for a 15-ft screen ($M = 218$), since it was known that results on even a 20-ft screen would then be entirely acceptable.

Accordingly, the Stereomeasure was permanently set at $M = 218$, this being analogous to the choice of a film emulsion for a production, which gives rise to a fixed speed setting on the exposure meter. While the movement of the camera on its crane was being rehearsed, distance measurements were taken from it to the dancer and to different parts of the set. These measurements were made with the special Stereotape graduated in ρ on one side and linear units (for focusing) on the other.

For the first shot, the entry in the stereotechnician's log begins as follows:

> *Slate 35:* LS Prince (John Field), who dances his Variation. Rear of set at 10ρ. During the dance, camera tracks in, and the Prince finishes in MLS at 33ρ. At end of dance, as Prince kneels, banners rise in front of him, covering whole frame, at 65ρ from camera. For continuity with following shot (already taken), banners should be at or around $N_{2.75}$.

It should first be determined whether this shot can be made with $B = 0$, i.e. with linear transmission, placing D_0 at 0ρ. Since the banners are to appear at $N_{2.75}$, the depth range is $\Delta_{2.75}$. The cameraman having selected a 35mm lens ($f_c = 1.38$ in.), it can readily be determined by Eq. (8), or from the Stereomeasure, that $t_c = 2.1$ in. However, this value of t_c is not obtainable on our camera with the 35mm lens, and the shot must therefore be recalculated for $B+$. The simplest procedure is as follows.

Taking the minimum setting of t_c (i.e. 2.5 in.), we then have M, f_c and t_c, and therefore the C factor. The most distant plane in the set, 10ρ (i.e. 50 ft), is set at infinity, D_0. The Stereomeasure, solving Eq. (8) directly, gives 30ρ as the value of D_1, and shows that the banners will in fact appear at $N_{2.75}$.

Hence the stereotechnician's entry concludes,

> Treat shot as $B+$, with $f_c = 35$mm, $t_c = 2.5$ in., and cot $\varphi = 160$. D_1 to be at 30ρ. Nearness factor of raised banners works out at $N_{2.75}$, as desired.

These measurements and calculator readings occupy only a couple of minutes, and in a few moments more the camera is set to $t_c = 2.5$ in. and cot $\varphi = 160$, the latter value having been obtained from scales on the Stereomeasure which relate t_c and D_1, as in Eq. (9).

Two further points deserve comment. Firstly, what could have been done if the proposed settings had placed the banners in the wrong plane in theater space? Had they proved too far away, it would have been possible (a) to reduce the distance in the studio between camera and banners, (b) to increase f_c, or (c) to increase t_c. Both (a) and (b) alter the composition of the shot, and so (c) is usually the preferable alternative. Had the banners proved to have too great a nearness factor, it would have been necessary to resort to the inverse procedure of (a) or (b), since the t_c setting was already a minimum; This points to the need of incorporating the lowest practicable minimum t_c in the design of the camera.

Secondly, it may be asked what effect on the appearance of the shot is likely to result from changing $B = 0$ to $B+$. Setting the rearmost plane at D_0 should of course place it at infinity, and clever set design will in fact produce a very

* The excessive positive z_s resulting from projection with too large a value of M can be corrected by supplying a negative correction of suitable size which will alter B and increase the N value of the nearest planes. This can be done by projecting with z_{CL} negative, but better by optical correction. Note that N factors will be increased *both* by the larger M and by the extra negative screen parallax.

marked elongation, an advantage when designing spectacular scenes. The backgrounds of normal interior sets are not likely, however, to suffer any appreciable deformation. It is the foregrounds, especially when they contain objects of familiar shape, which may be more visibly distorted. An example of a visible kind of stereo distortion is worked out from the data on the following shot. Practice, and frequent viewing of 3-D films, will tell the stereotechnician what is acceptable and what is not. It is unlikely, however, that he will satisfy everyone; for reasons that are not yet clear, people differ enormously in their sensitivity to stereoscopic shape and size.

When the stereo settings have been made, one more step is required to be taken before the camera is ready to roll. This is the Stereotest, which provides the necessary data under the microscope to determine the actual, as contrasted with the nominal, values of cot φ (or h) and t_c. To make this test, a small target board resembling a ping-pong bat is run out first to a distance of 40ρ and then to 22ρ with the aid of the Stereotape, a few frames of film being exposed at each distance. The lens focus is set at 15 ft for both shots, since the lens-to-film distance enters into the equations, and must therefore remain constant.

The shot which follows Slate 35 in the film had already been taken. It was the nearness of its front banner which had to be exceeded in 35, in order to produce the desired progression in space. The entry in the stereocontinuity book is as follows:

> *Slate 15:* Shot opens with pair of banners in CS, filling screen, at 79ρ (6 ft 4 in.). Banners raised out of picture to reveal further pair, and so on, till raising of 4th pair reveals Odile (Beryl Grey) in LS, who starts to dance her Variation. Camera static, rear of set at 13ρ (39 ft). At end of slate, Odile has danced into MS at 48ρ (10 ft 5 in.).
>
> Treat shot as $B+$, with $f_c = 50$ mm, $t_c = 1.25$ in. and cot $\varphi = 220$. Thus $D_0 = 13\rho$, $D_1 = 44\rho$, and $D_2 = 75\rho$, since $\Delta_1 = 31\rho$. Hence front banner is slightly closer than N_2, actually $N_{2,13}$.

The method of working out this shot need not be repeated here, since it resembles the previous example and can be checked with the help of the equations already given. Although the stereotechnician will seldom have to force the cameraman's hand in the choice of lenses, or the director's in the arrangement of a scene, he is nevertheless bound to be constantly preoccupied with the smallest value of t_c which his equipment will provide. In studio work, with its large depth ranges, he is likely to be pressing against this limit much of the time. In Slate 15, for example, 1.25 in. was the absolute minimum t_c available with the 50-mm lens, and had it been desired to hold the nearest banner farther away than $N_{2.1}$, while retaining it at the same field size, nothing could have been done — except by allowing divergence to occur in the farthest planes of the shot.

Image Distortion in the Theater

The data already provided for Slate 15 makes another interesting analysis possible; by studying the shape of different parts of the image, it is possible to get a clearer idea of the distortions set up in the motion picture theater. Let us consider the plane in the image corresponding to Beryl Grey's position when she has danced forward at the end of the shot, and is at 48ρ. The spectator is assumed to be at a distance from the screen of $2.5W$.

> *Example:* It is required to find the depth magnification, width magnification and shape ratio for Slate 15 at a plane in the scene distant 48ρ from the camera, when the spectator is seated at $2.5W$ from the screen for which the film was shot.

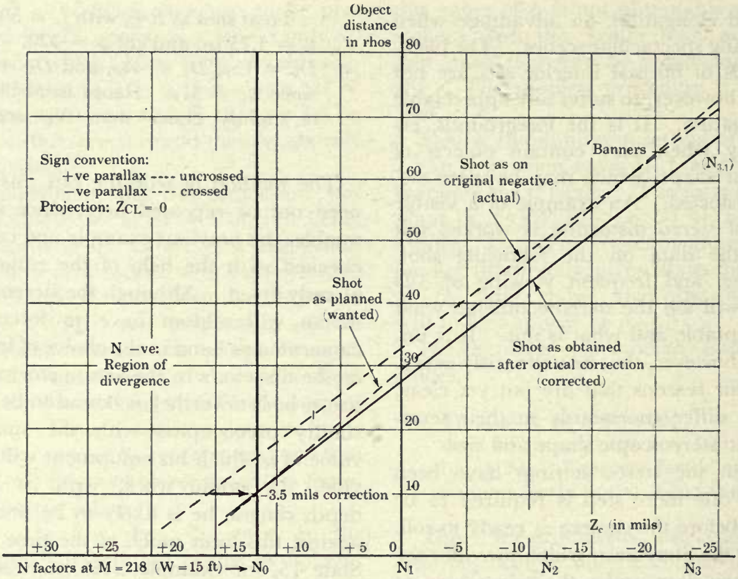


Fig. 8. Graphical analysis of Slate 35 of *The Black Swan*, showing relation between object distances in scene and nearness factors in cinema, together with method of postcorrection of convergence errors by optical printing.

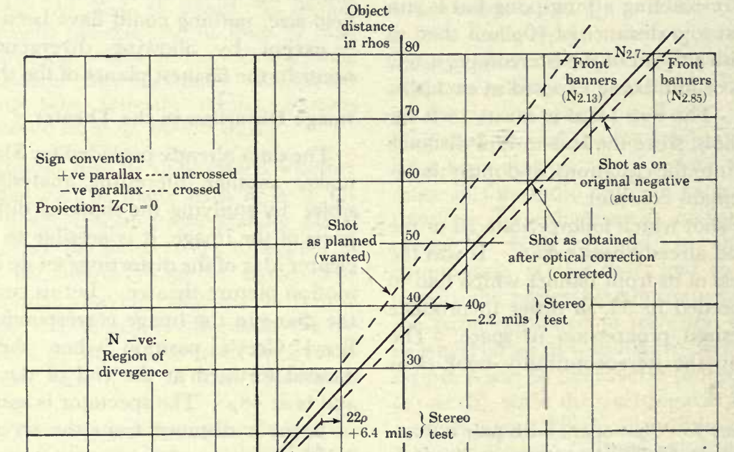


Fig. 9. Graphical analysis of Slate 15 of *The Black Swan*, as Fig. 8, but showing also how the Stereotest readings are plotted to give the depth relationships on the camera negative.

Data: $M = 218$, $\therefore W = 15$ ft, and $2.5\,W = 450$ in., $\therefore A = 1{,}125$ sq in.
$D_1 = 44\rho$, $\therefore 48\rho = N_{1\cdot 09}$.
$f_c = 50$ mm $= 1.97$ in., $t_c = 1.25$ in., $\therefore C = 536.9$ sq in.

From Eq. (14),

$$B = \frac{536.9 \times 44}{6{,}000} - 2.5$$
$$= 1.44 \text{ in.}$$
$$\left(\frac{B}{Nt} + 1\right) = 1.53$$
$$\left(\frac{B}{Nt} + 1\right)^2 = 2.34$$

Hence, from Eqs. (11), (12) and (13),

$$m_d = 2.10 \times 2.34 = 4.9$$
$$m_w = 2.00 \times 1.53 = 3.1$$
$$\mu = 4.9/3.1 = 1.6$$

From this it is safe to conclude, and can indeed be observed in the film, that some elongation of the side of the face and the shoulders will be noticeable, especially if the dancer turns so that the same features undergo differing magnification in quick succession. The more interesting case in which the dancer pirouettes with outstretched arms would call for integration, since the depth occupied by the arm stretching toward the camera would be nonlinearly magnified in a $B+$ system. This difficulty can be overcome by employing an extension of the technique next to be described.

Interpreting the Stereotest

A graphical presentation, based on the principle of Fig. 3, greatly simplifies the study of scenes in space. So long as the distance of a plane in the scene from the camera is known, its position in space in the theater can be read off in an instant, together with the parallax which a point in this plane has produced on the camera negative, and finally the convergence and interaxial separation which obtained when the scene was shot. Figures 8 and 9 are the representation of Slates 35 and 15 respectively in *The Black Swan.* After development, synchronized left- and right-eye frames of the two Stereotests are cut from the negative tracks and placed under a special Swift traveling microscope with pilot-pin registration. By placing the two frames successively on the same pins, the parallax between corresponding points on the tests, at each distance, can be read off with great accuracy. These results from the actual film may be tabulated as in Table IV.

Table IV

	z_c (mils) 40ρ	22ρ
Slate 35	−4.3	+7.2
Slate 15	−2.2	+6.4

It should be emphasized that, because of the extremely small parallaxes needed to produce a δN of only 0.1 (see Table III), the most painstaking efforts must be made to keep microscope reading errors down to the lowest possible limits. Figures 8 and 9 show how the 40 and 22 ρ points are plotted on a graph which represents z_c on the x-axis and distances in ρ on the y-axis. Since, on such a graph, $B = 0$, $B+$ and $B-$ systems are equally represented by straight lines, it is only necessary to lay a ruler between the 40ρ and the 22ρ points. The resulting line represents all the stereoscopic relationships in the negative, and the x-axis can of course be additionally graduated in N values for any assumed value of M by using the relationship,

$$N = 1 - \frac{Mz_c}{t} \qquad (11)$$

In Figs. 8 and 9 this has been done for $M = 218$, the magnification for which the film was shot.

With the aid of a special protractor (not shown in the diagrams), it is possible to read off with great accuracy the actual values of t_c and φ (or h) which obtained when shooting. These results may be tabulated as in Table V.

No practical technique is imaginable for changing the magnitude of the C factor after shooting (assuming that M re-

Table V

	cot φ Wanted	cot φ Actual	t_c (in in.) Wanted	t_c (in in.) Actual
Slate 35	160	145	2.5	2.72
Slate 15	220	234	1.25	1.42

mains fixed), and therefore the slight error in t_c will result in any given span of distances in the scene occupying a somewhat greater span of nearness factors in the cinema than the stereotechnician intended. On the other hand, errors in the B factor resulting from inaccurate convergence can be perfectly corrected in an optical printing stage. This is because convergence is essentially no more than the sideways displacement of the films relative to the images formed on them by the lenses, a fact which is easy to recognize in the case of h, but which applies also to φ. The method of correction will be apparent from Figs. 8 and 9. We know from the entries in the stereocontinuity log the ρ distances which were supposed to correspond with D_0 and D_1 (i.e. N_0 and N_1 in the theater); in Slate 35, $D_0 = 10\rho$, and $D_1 = 30\rho$; in Slate 15, $D_0 = 13\rho$ and $D_1 = 44\rho$. These pairs of points enable us to plot the "Wanted" curves for these shots. Figure 8 shows that the N_0 (D_0) line cuts the "Wanted" curve at 10ρ, but the "Actual" curve at 15ρ, thus indicating that an increasing amount of divergence will be introduced at $M = 218$ for scene distances greater than 15ρ. Figure 8 also shows that by displacing the "Actual" curve sideways and in the increasing negative direction through 3.5 mils (as measured on the x-axis), N_0 will be reestablished at 10ρ, thus producing the "Corrected" curve. This is equivalent to giving the image a lateral displacement in relation to the perforations of -3.5 mils, and this figure is accordingly entered in the correction table for the film. The reason why the "Corrected" curve still differs from the "Wanted" curve is, as explained above, that t_c is slightly greater than it should be. This decreases the gradient of the curve, and thus amplifies the change in N values for any given range of object distances.

A correction of 3.5 mils corresponds to a change of nearness factor (δN) of 0.3 at $M = 218$. Corrections with this particular camera tend, however, to run much higher, averaging about 10 mils and sometimes exceeding 25 mils ($\delta N = 2.2$ at $M = 218$). This would mean that an object at infinity would be represented stereoscopically as halfway from the screen to the spectator, or vice versa — an error which would, of course, completely destroy the 3-D effect of the scene. With screens of larger size than 15 ft, the error would be even greater.

The result of the correction to Slate 35 is that D_0 is now correctly placed at N_0 when projected with $M = 218$. Had there been no error in t_c, all other points in the scene would also have been correctly placed. As it is, the banners at the end of the shot project in the theater at $N_{3.1}$ instead of at $N_{2.75}$ as planned.

The analysis of Slate 15 (Fig. 9) is carried out in exactly the same way, and here the correction is found to be $+0.8$ mils, the smallest ever encountered, the plane of D_0 having been moved back merely from 13ρ to 11.5ρ.

When better camera equipment is available, correction of every shot in this way will not of course be necessary. The technique of the stereotest will, however, continue to be useful as a laboratory check on the accuracy of the very precise camera adjustments required — much as the routine D-log E curve provides a daily or hourly check on film processing. But this by no means exhausts the possibilities of graphical analysis and optical stereo correction. For instance, when the layout of a set design is available, it becomes possible to study the mechanics of a complicated 3-D shot long before the film reaches the studio. Planes in space can be accurately charted, the necessary camera constants determined, and if the shot proves impossible, alterations can

be made in the set before rather than after construction takes place. Again, when the public learns how to look at quick-cutting sequences in 3-D, it will often be possible to build these up out of material shot with an ordinary "flat" camera, giving each shot a single plane in space by means of optical printing, and varying this plane if necessary by means of optical zooms. The construction of such a sequence is greatly simplified if it can be plotted in space, with the optical corrections read off from the graphs. The same technique may be applied during the editing stage of an ordinary 3-D film to readjust a shot which does not fit into the space continuity finally decided on. And lastly, optical printing may be used to match infinity points (or any other points) in converting films to use on very large or very small screens.

Since optical printing is necessary with our camera to provide left-to-right image reversal, the transfer from original negative to master positive is made use of also for the stereo correction and for the introduction of the necessary optical effects. Duping and printing then become normal contact processes. There are of course limits to the width of the stereo correction which can be printed on a single film without trespassing too close to the final projector aperture. If the correction is too large, it must be split between the two bands of film. However, the larger the screen for which the film is shot, the smaller the absolute magnitude of the corrections. Furthermore, an additional width is provided for the corrections on each film by the printed-on stereo window.

The Stereo Window

This is the last printing stage to which the film must be submitted. *The Black Swan* has a fixed stereo window at approximately N_2 (with $M = 218$), containing patented fusible components along its top and bottom edges, so that these contribute to the stereoscopic effect nearly as much as do the vertical sides. The window also could be incorporated at the master positive stage, but extremely high contrast is necessary in a traveling matte to avoid fogging the image, and it is therefore best printed on at the release print stage.

The stereo window is an essential component of most 3-D films, and its existence and position in space must be contemplated from the beginning. More than half of the shots in *The Black Swan* were designed to occupy the full stereoscopic space between N_0 and N_2 (i.e. ${}^{\Delta}N_2$); but as the scene was a ballet stage with dancers on it, effective space would have been seriously telescoped had not a forward window permitted a free movement of the image out to a distance halfway between the screen and the spectator.

Appearance of the Scene in the Theater

It is now time to stand back from the technicalities of production and ask how the two shots we have so often referred to appear to the ordinary audience in the movie theater. In the first place, whether they are conscious of it or not, spectators will see the entire scene framed behind the forward window, with the exception of one or two self-supporting objects such as the banners in Slate 35 and Beryl Grey's arms and back-bent body in several shots. Since the screen, if free from blemishes, becomes invisible in a 3-D film, the window is easily mistaken for it. Thus an audience might be led to comment on *The Black Swan*, "Practically nothing comes out in front of the screen," although, in point of fact, almost half the film does so. But the actual — even if unrecognized — use of theater space has one extremely important advantage which we have often heard commented on during commercial presentations of the films. Because of the increase of stereoscopic depth magnification (m_d) with distance from the screen, the spectator in the most distant balcony seat has a view of the film which is just as dramatically effective as that ob-

tained by a person sitting comparatively close to the screen.

In a stereocinema, distortions are usually least at a seating distance of 2 to 2.5 W, and if — but only if — the picture has been shot so as to be acceptable from this position, it will not as a rule appear unnaturally elongated even if viewed from much farther away. This is due to the inverse effects of m_b and m_w described under the heading "Binocular Magnification," earlier in this paper. Practical viewing experience reveals a substantial constancy in the depth-appearance of the image between the front and back seats of any normal theater; but this will only be true if N values of 2 or more are employed continuously, for otherwise the distant spectator will become conscious of the gap existing between himself and the screen. In our experience, provided that a sufficiently high level of technical perfection is achieved in the production and projection of a 3-D film, nearness values as high as N_3 can be held continuously (for example, in a stereo window), with much larger values for the normal duration of an especially dramatic scene.

Granted, then, that the scene in *The Black Swan* will be framed in an N_2 window; and that the audience, though for the most part unconscious of this fact, will be aware of seeing a picture totally different from the normal one, and different too from a stereo film presented wholly behind the plane of the screen. Granted this, what else will the audience be aware of? In the first place, the fact that their eyes can now scan the scene in depth means that the visual content of each shot will be much increased, and this in turn necessitates holding the shot longer on the screen. Today, when few audiences have seen 3-D films before, quick cutting is ineffective, since each shot takes an appreciable time to establish itself, after which its quick disappearance produces an effect of disappointment and even annoyance. This is an extension of the principle on which color films tend to be cut somewhat slower than black-and-white ones. Secondly, the audience will be much more aware of the importance of depth relationships in a scene. Figure 10 shows a shot in *The Black Swan* which is of a type particularly impressive in 3-D. Whereas in a flat film it would achieve no more than the normal effects of deep focus, the third dimension gives the foreground figure an almost physical effect of size and massiveness. Even when the spectator is consciously watching the White Swan trying to make her presence noticed, he feels his eyes drawn to the menacing figure of the Enchanter standing much closer in the foreground and trying to banish her away.

In the third place, the audience almost completely loses the impression that it is watching the photographic rendering of a scene. Actual reality seems to lie before it, and when the film is in color this reality is almost complete.

Thus in the first scene we have been considering, the Male Variation danced by John Field will appear almost as if one were present in the theater. The raising of the banners right in front of the eyes produces by contrast a momentary feeling of complete surprise; and after a brief pause, the successive lifting of four pairs of banners out of scene — flowing in the same unbroken rhythm — disguises the fact that the scene has changed and thus introduces an element of fantasy when both a new decor and a different dancer are revealed.

Part III: A Critique of Existing Procedures

It may well be asked how, in the absence of a general transmission theory, proper camera and projection conditions could have been set up for the stereoscopic films produced up to now and those in current production by other

Fig. 10. The third dimension in this type of shot gives the foreground figure an almost physical effect of size and massiveness.

groups. The answer is threefold. First, the basis of an accurate theory was laid just prior to the war by Professor J. T. Rule,[5] and was apparently used by J. A. Norling in the production of his well-known and very successful films. Second, a number of pictures have been produced outside the United States on the basis of no proper transmission theory at all, severe eyestrain having been avoided only because the size of the projection screen was very small. Third, and most recently, the early work of Rule has been overlooked or ignored, and a number of simplified procedures have been suggested, many of them the subject of exaggerated claims, such as that they completely eliminate distortion, or that they make 3-D filming

conform to the procedures of the flat film, yet without loss of effect.

In this Part we shall discuss in some detail, using the method of analysis already derived from the general theory, two typical proposals, both in current use and both claimed to provide a perfect solution to all problems of stereoscopic transmission. The first makes use of a fixed interaxial separation of the camera lenses, and a variable convergence; in the second the convergence is fixed, but the interaxial separation is made variable.

Viewing of Real Objects and Stereo Images

It has been suggested — notably by Dewhurst[9] in Great Britain and more recently by an influential group in the U.S. — that the problem of 3-D filming is very simple: all that is necessary is to provide a fixed lens separation (t_c) approximating that of the human eyes and then converge the optical systems on some appropriate plane in the scene — this plane appearing, of course, in the plane of the screen when the film is projected with $z_{CL} = 0$. It has been further suggested that the convergence control ought to be coupled to the lens-focusing mechanism in such a way that D_1 is always the distance to the plane of sharpest focus. Thus, following focus would automatically alter the convergence, and (since t_c is already fixed) no special stereoscopic adjustments of any kind would require to be made. This, it is held, would reproduce the conditions of natural vision, and would provide strain-free viewing of the image by all spectators.*

* The same idea has recently occurred to the first producer of 3-D motion pictures in Hungary, M. Felix Bodrossy. "The Hungarian method," he writes, "solves the problem simply and radically: it starts off from the way the eyes work, and imitates nature. The eyes always focus automatically and at the same time converge on the object they look at. Our cameras do the same thing."[10]

The parallel with the human eyes is simple and attractive; but, from what has been said above, it will be apparent that the viewing of a stereoscopic image cannot at present be made to resemble human vision at all closely. The image in space is not even an optical image; it is a mental construction from data supplied solely by overlapped images on a flat screen. This construction is accomplished by methods not used in normal vision; for example, the spectator's eyes must remain focused at the screen distance, but they will be varyingly converged according to the distance of the point of attention, which may be much nearer or much more remote. Furthermore, in the real world, sense-data remain more or less constant when spectator and scene are fixed; but stereoscopic data may be made to vary widely according to projection conditions, and indeed cannot be kept constant when the size of the screen is changed. It is therefore not to be expected that a mere reproduction at the camera of the human eye separation — in the absence of human viewing methods — will of itself produce strain-free viewing. This cannot be so simply achieved until it becomes possible to create real or virtual 3-D images in space.

Limitations of Fixed-t_c Systems

Meanwhile, stereo camera systems which make use of a fixed "human" lens separation of 2.5 in. must be treated as having an awkward limitation common to all fixed lens systems designed to film pictures for large screens. The transmission system obtaining with a fixed value of t_c can be very clearly exhibited on a graph similar to Figs. 8 and 9. Reference to the section "Depth Range in the Scene," earlier in this paper, will show that the slope of the transmission lines is a function of the C factor (i.e. Mf_ct_c) and t; and therefore, if M is assumed fixed for the film, t_c is fixed on principle, and f_c represents the focal length of the lens in use, all possible trans-

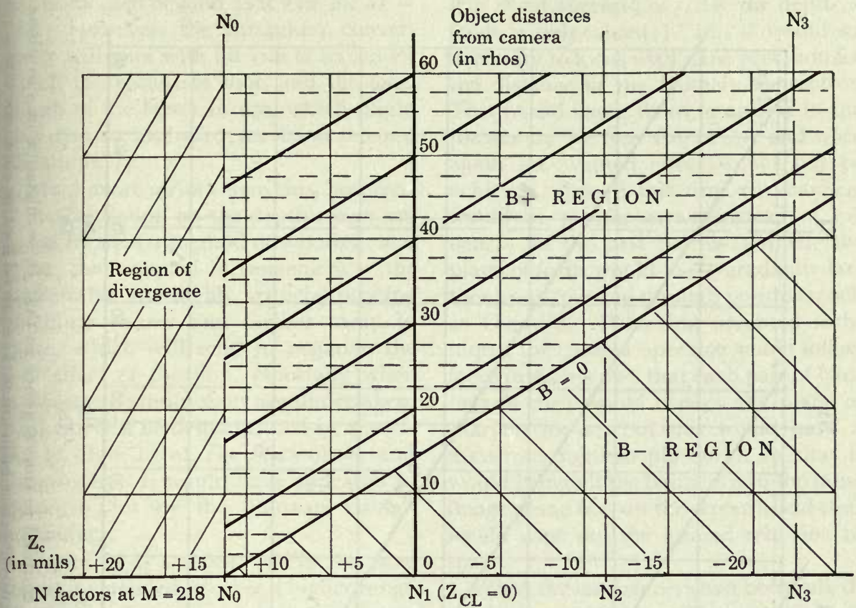


Fig. 11. Graphical analysis of "human vision" technique (i.e., t_c fixed at 2.5 in.). For $M = 218, f_c = 50$mm, all depth range possibilities are comprised in a series of parallel lines, such as those shown at 10ρ intervals, in the horizontally shaded region bounded by $B = 0$. For ρ values > 60 (distances < 8 ft 4 in.), extend the graph upward; for $N > 3$, extend it to the right. For $f_c > 50$mm, the parallel lines slope proportionately less steeply, and the depth range decreases; for $f_c < 50$mm, these lines slope more steeply, and the depth range increases. For $M > 218$, the region of divergence extends to the right, the intervals N_0, N_1, N_2 . . . becoming proportionately smaller, N_1 remaining at $z_c = 0$.

mission lines on the graph will have the same slope, and must therefore run parallel to one another.*

Figure 11 displays all the possibilities of such a transmission system, assuming $t_c = 2.5$ in., and taking $M = 218$ and $f_c = 50$ mm (i.e. 1.97 in.), so as to enable a direct comparison to be made with the shooting of Slate 15 of *The Black Swan.*

Then, from Eq. (8b),

$$D_1 - D_0 = \frac{2.5 \times 6{,}000}{218 \times 1.97 \times 2.5} \text{ rhos} = 13.97 \text{ rhos.}$$

This enables us to draw the $B=0$ line in Fig. 11, which also shows representative transmission lines drawn in at arbitrary intervals of 10ρ. The area under the $B=0$ line represents the $B-$ type of transmission, which gives rise to cardboarding and is therefore almost always undesirable; hence the camera convergence must never be set to give D_1 less than 13.97ρ (i.e. d_1 more than 35 ft 9 in.). When the lenses are focused at infinity, they must not, as might be expected, be aligned with their axes parallel; alternatively, if the lens and convergence mechanisms are coupled, the lenses must

* When the focus and convergence are coupled, this statement is not strictly true, for f_c is properly the lens-to-film distance, which increases slightly as the lens is focused nearer. Hence, as D_1 is brought nearer to the camera, the C factor will increase slightly and the depth range will be correspondingly reduced. This is a second-order error, which is ignored in Fig. 11.

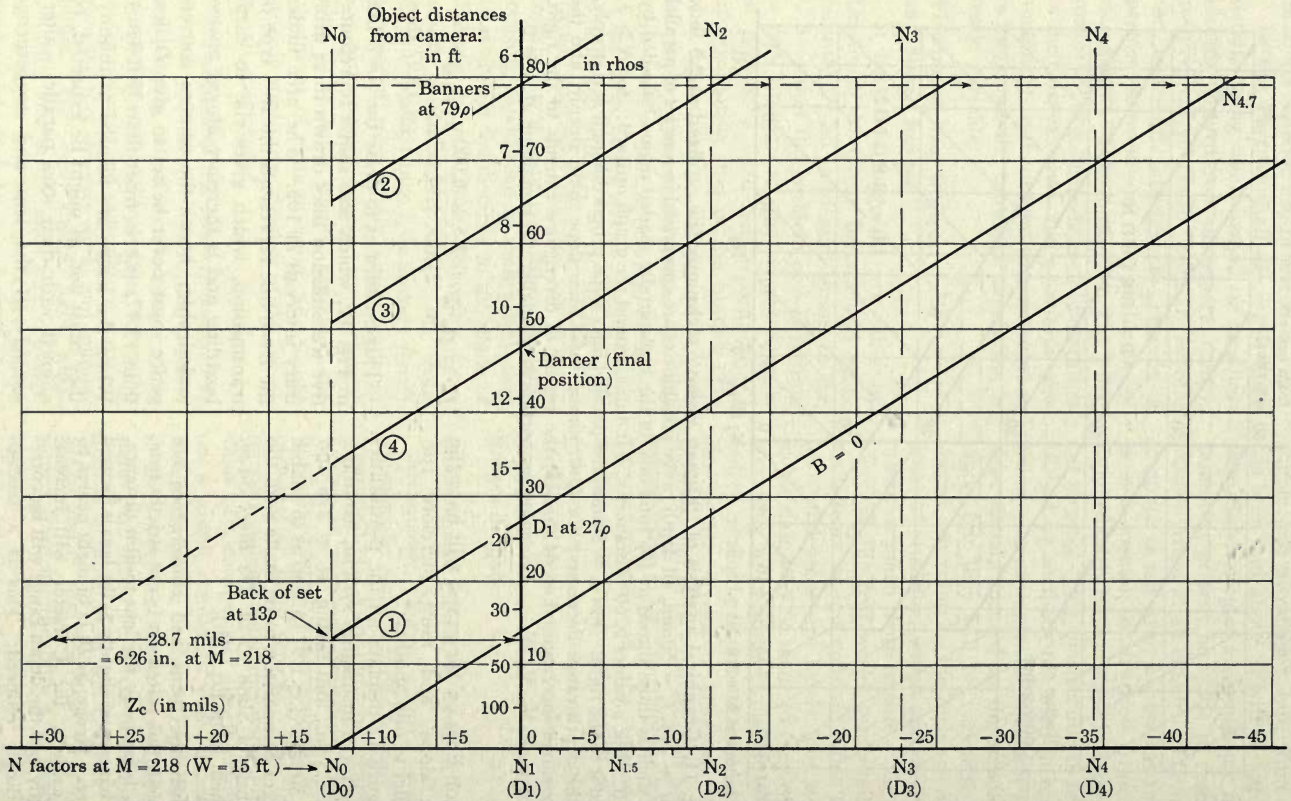


Fig. 12. Slate 15, *The Black Swan*, as if shot by "human vision" with focus coupled to convergence so that D_1 = distance in ρ to plane of sharpest focus. Data as for Fig. 11. Curves 1–4 show successive convergence adjustments required for this shot (see text).

not be focused beyond 35 ft 9 in. for $M = 218$. However, the minimum convergence will alter with the size of screen for which the picture is shot, and the focal length of the lenses in use, which might give rise to awkward mechanical complications.

Much more serious than this, however, is the restriction on the depth range imposed by such a method of shooting, and — in the coupled arrangement — the undesirable and highly artificial pushing of things nearer and farther away in space, which will tend to negative the 3-D effect of the film, especially when complicated studio shots are undertaken. This can best be demonstrated by reverting to Slate 15 of *The Black Swan*, and showing how it would have appeared in space if shot by the "human vision" technique.

Figure 12 is a repeat of Fig. 11, save that it is extended to cover a higher range of nearness factors, and is marked with the actual distances found in Slate 15. Curve 1 shows the result of setting the back of the scene (13ρ) at infinity, i.e. at D_0, the method employed in the actual shooting. But now the front set of banners (at 79ρ) will come out to $N_{4.7}$, i.e. $(79 - 13)/13.97$, which is almost $\frac{4}{5}$ of the distance from the screen to any spectator. This is much closer than the cutting continuity allows, and, in the opinion of many, enters the region of eyestrain. Certainly, the extreme nearness of the banners would be quite out of keeping with the rest of the film. No other fixed setting is possible, since it would produce divergence on the back of the set, even with the extremely modest assumed magnification of 218 (i.e. a 15-ft image in the theater).

Thus a variable convergence for this shot is required by the "human vision" system under discussion, and we may conveniently assume that the convergence is coupled to the lens focus system in the way already described. The shot opens with the banners at 79ρ (6 ft 4 in.), and since at this distance, using a 50-mm lens at an aperture of $f/2.8$, the depth of focus is only about 17 in., it would be necessary to focus with some precision for the distance of the banners themselves. This would cause them to appear in the theater at N_1 (see Curve 2), and once again the wanted effect would not be achieved, though this time the banners would be too far away, instead of too near. As the first pair was lifted, the plane of focus would move gradually farther away, passing through positions such as Curve 3. Following accepted technique, the camera operator would follow focus in such a way that each pair of banners in turn would occupy the plane of sharpest focus; but this would have a disastrous stereoscopic effect, in that it would bring all the banners into the same image plane (i.e. on the screen), and thus would wipe out the wanted recession in space.

When the last banners had been raised, the focus would rest at 27ρ, and the back of the set would be correctly placed at 13ρ. But towards the end of the shot, Beryl Grey dances forward to 48ρ from camera, where she would be out of focus. It is therefore necessary to alter focus again, and according to normal practice, the dancer would be held in the plane of sharpest focus, shown as Curve 4 in Fig. 12. This would not only completely neutralize her forward movement in space, but would create divergence on the background, which would still be sufficiently in focus to be fusible. The only way out of the dilemma of neutralizing depth is to juggle with the depth of focus, placing very near objects at the limit of the zone of acceptable sharpness in order to correct as well as possible their misplacement in space. This procedure would unquestionably be much more inconvenient than having independently adjustable stereo settings for it would contradict accepted camera practice and would give rise to a method of shooting in which the sharpness of focus was always under suspicion.

The problem of divergence is even

more intractable. Figure 12 shows that points at 13ρ will be separated by 6.26 in. on the screen instead of the proper 2.5 in., which would induce serious eyestrain, especially for spectators in the front rows of seats. If the magnification is raised from 218 to 300 (i.e. a screen width of 20 ft 8 in.), the separation on background points would amount to 8.6 in., more than three times the separation of the human eyes. It should be remembered that divergence does not occur at all in natural vision; its physiological effect can be extremely uncomfortable.

Distortions With Fixed-t_c Systems

But this is not the last of the disadvantages of a "human vision" camera arrangement. The use of large B factors entailed by employing a value of t_c which is often too big for the size of screen and the depth range to be compassed, leads to serious distortion of the shape of objects, as may be seen by a comparison of the example worked out under "Image Distortion in the Theater," earlier in this paper, with the same scene shot according to the precepts of "human vision." The data will be exactly the same, save that t_c = 2.5 in. instead of 1.25 in., and that the dancer (who will be in the plane of sharpest focus) will be moved very slightly back from $N_{1.09}$ to N_1. When these new values have been substituted, along with the unchanged data, in Eqs. (11) to (13), the results in Table VI are obtained, which for convenience are placed alongside the characteristics of the shot in the film.

Table VI. *The Black Swan*, Slate 15, Stereo Distortions at the Plane of the Dancer's Final Position. M = 218; $V = 2.5W$.

	By "human vision"	In the film
m_d	12.4	4.9
m_w	3.4	3.1
μ	3.6	1.6

What has happened with "human vision" is that the width magnification has been kept down by making t_c equal to t, which is one of the conditions for ensuring that m_w = 1 (see Eq. (15)). On the other hand, the depth magnification has increased enormously owing to the squared term in Eq. (11), and this has more than doubled the distortion of shape, as indicated by the figures for the shape ratio.

This consequence of a "human vision" approach can be even more clearly demonstrated by the graphical technique already described. Figure 13 is in essence an enlargement of the relevant part of Fig. 12. It shows Beryl Grey's shoulder placed at 48ρ (10 ft 5 in.) from the camera, with arm outstretched as she pirouettes, so that the fingers are at 60ρ (8 ft 4 in.). The x-axis has been graduated in N values, so that the value of P (distance from spectator to a point in the image) can be readily calculated from Eq. (1). By taking two points, one at the shoulder and one at the fingertips, the actual stereoscopic length of the arm can be found by simple subtraction, in spite of the fact that the magnification varies nonlinearly between the two points. Figure 13 shows that the arm length, as shot for *The Black Swan*, is 102 in., whereas by "human vision" principles it would have been 208 in., or more than twice as great. The overall depth magnification works out as 4.1 in the first case, and 8.3 in the second, since the real arm length is 25 in.* As the dancer continues her pirouette, her outstretched arm moves into a plane parallel with that of the camera lenses, where its magnification will be uniform, and is given by m_w in Table VI. The two shape ratios are therefore 1.2 for the film and 2.4 for "human vision," which is again twice as much distorted.

* The overall magnification is of course lower than the magnification at the shoulder, because m_d decreases as N increases, and is therefore least at the fingertips.

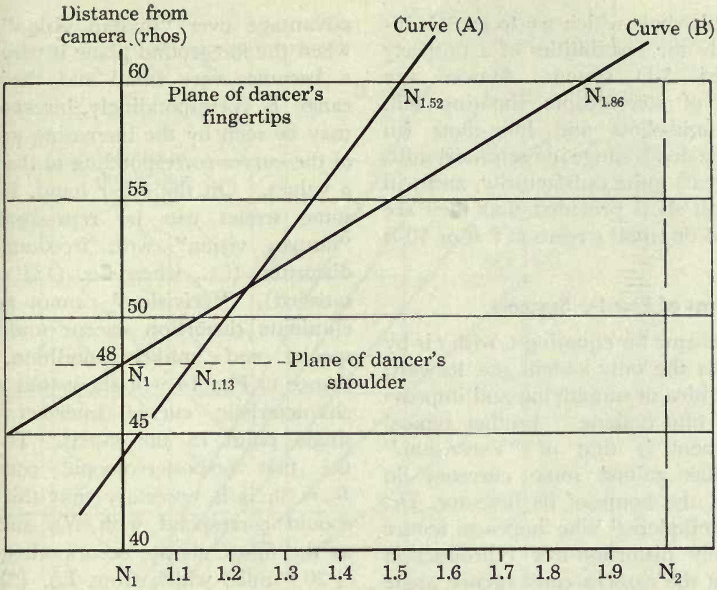


Fig. 13. Enlarged section of Fig. 12, with "human vision" rendering of Slate 15 (Curve B) compared with shot in film (Curve A). N values may be converted to image distances from spectator (P) by Eq. (1) ($P = V/N$). Assume spectator seated at $2.5W$, i.e., 450 in. from 15 ft screen. Let P = image distance to dancer's shoulder, P' to her fingertips, when her arm is outstretched to the spectator. Hence, stereoscopic length of dancer's arm = $P - P'$.

From Curve B, "human vision," $P = 450/1$, $P' = 450/1.86$, $\therefore P - P' = 208$ in.

From Curve A, shot in film, $P = 450/1.13$, $P' = 450/1.52$, $\therefore P - P' = 102$ in.

The general applicability of a "human vision" technique can perhaps be most quickly judged by a statistical summary of the t_c values employed in some recent pictures. The settings indicated by calculators such as the Stereomeasure and the Polaroid Interocular Calculator naturally give no preference to the value of 2.5 in., which is merely one setting in a wide and infinitely divisible range; but if, to give "human vision" all permissible latitude, we assign it the whole span of t_c values between 2.3 in. and 2.7 in., we can analyze its limitations in the light of actual t_c figures from productions. Picture A is a studio film shot in sets of normal dimensions; Picture B is a documentary film shot principally out of doors.

Table VII. Number of Shots Lying Inside and Outside the "Human Vision" Range for Two Typical Productions

	Less than 2.3 in.	2.3–2.7 in.	More than 2.7 in.	Total
Picture A	16	20	1	37
Picture B	6	10	29	46

Thus 46% of the shots in Picture A, and 76% of those in Picture B, fall outside the "human vision" range when calculated according to the general theory, and without any preconception that t must always equal t_c. It must be remembered that the scene we have been discussing in such detail is not in any way abnormal, but is representative of in-

numerable shots which try to exploit intelligently the possibilities of a properly conceived 3-D system. Almost any method of stereoscopic shooting will handle mid-shots and long-shots (in which the depth range in reciprocal units is not great) quite satisfactorily, and will handle all shots provided that they are projected on small screens of 8-ft or 10-ft width.

Limitations of Fixed-φ Systems

The scheme for equating t_c with t is by no means the only system put forward with the idea of simplifying and improving 3-D film making. Another typical arrangement is that of "Verivision," which has gained some currency in Holland, the home of its inventor, Dr. F. H. Reijnders,[11] who hopes to secure completely distortion-free reproduction by fixing the camera convergence angle permanently at $\varphi = 0.3°$.* At the same time t_c is made variable, and set at such a figure that the fixedly converged lens axes always intersect in the nearest plane of the scene.

It can readily be shown that "Verivision" (which disregards the effect of screen size) reduces to the simple relationship $D_0 = 0.44D_1$. This is graphed for distance increments of 10 ρ in Fig. 14, which clearly shows the possibilities and limitations of the system.† It has the advantage over "human vision" that, when the foreground plane is very close, t_c becomes very small and the depth range is correspondingly increased, as may be seen by the increasing gradient of the curves corresponding to the larger ρ values. On the other hand, whereas some scenes can be reproduced by "human vision" with freedom from distortion (i.e., when Eq. (15) can be satisfied), "Verivision" cannot possibly eliminate distortion except under one special and unlikely condition. Reference to Fig. 14 will show that all the characteristic curves intersect at a single point in the x-axis. To meet the first orthostereoscopic condition, $B = 0$, it is necessary that this point should correspond with N_0, and this, as the figure shows, occurs when $z_c = +20.5$ mils, which from Eq. (3) gives $M = 122$, corresponding to a screen width of 8 ft 4 in., a size not particularly well adapted to commercial production.

A further limitation of "Verivision" is that it imposes a method of filming which eliminates all N values greater than unity.

To sum up, it is incorrect to suppose that the functions of convergence and interaxial separation are interchangeable, and that either can be fixed at an arbitrary value without impairing the flexibility of the system. The B factor and the C factor are entirely distinct. Moreover, since the C factor cannot be altered after shooting (given the size of the screen), errors in t_c caused by incorrect filming methods cannot afterwards be amended.

* No explanation has been given for the choice of this particular angle, and Dr. Reijnders himself has prudently — though perhaps optimistically — claimed a patent on all values of φ between 0.15 and 0.6°.

† For purposes of comparison, the y-axis has been graduated with the values of t_c in mm obtained from Dr. Reijnders' formula for different values of D_1.

Part IV: Conclusions

Shooting a 3-D film demands two major changes in production methods: a change of attitude on the part of the director, and a change of camera technique.

The director of a 3-D film has an obligation to explore space relationships in his sets and between his characters which he would pass over in a normal flat film. If he neglects to do this, and merely em-

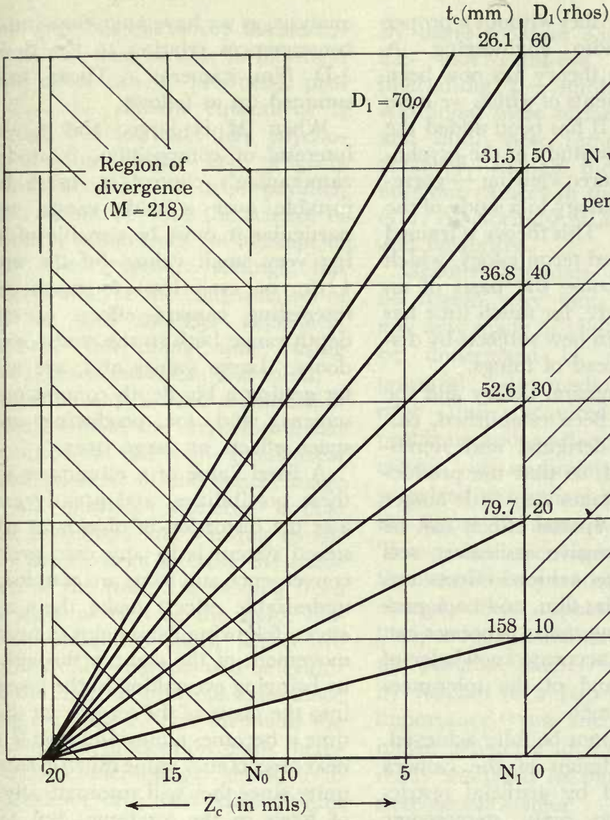


Fig. 14. Graphical analysis of "Verivision" technique (φ fixed at 0.3°, t_c adjusted so that optical axes intersect at D_1). Converging characteristics, shown at 10ρ intervals to 70ρ, show very limited depth range possibilities of the system, since only unshaded central area can be employed, and only that part of it bounded by available limiting values of t_c. Note that $B = 0$ only when point of intersection of characteristic curves occurs at N_0. This corresponds to $z_c = 20.5$ mils, or $M = 122$.

phasizes the extra dimension by placing some meaningless post or tree or lampstand in the foreground of each shot, the audience will become as weary of these tricks as they became of the endless knives, ladders and hurtling baseballs of the prewar anaglyphic pictures.

The left- or right-eye track of a 35-mm double-band stereo film may without modification be presented to a wider audience in unconverted theaters as a normal flat film. However, the more successfully the film's director has thought himself into the new world of the 3-D film, with its different space relations, rhythms of cutting, and use of optical effects, the less effective will be the flat version by comparison with what the same director would have made out of the same story had he concentrated on it alone.

The translation of the director's ideas into 3-D film demands a comprehensive knowledge of stereoscopic transmission theory — in just the same way as an electronic organ designer could not inter-

pret a musician's wishes without a proper grounding in audio engineering. A stereo transmission theory has now been evolved, some elements of which we have described; and to it has been added the beginnings of a new study of the psychological aspects of stereo viewing — corresponding in our analogy to a study of the modes of hearing. This theory is framed in a carefully studied terminology, which we hope may become the basis of an agreed nomenclature, for much time has often been wasted in new subjects by discussing names instead of things.

Once the transmission theory and the terminology have been established, calculators may be designed and stereotechnicians trained, so that the production of a 3-D film takes very little longer than a flat film. Spatial effects can be controlled with positive assurance, sets can be designed to achieve effects unobtainable in the flat film, and back projection and traveling matte processes can be developed with accurate knowledge of what is needed and of the tolerances which have to be met.

These things cannot be fully achieved, however, if the design of the camera has been cramped by artificial restrictions on the two main stereoscopic variables. Pictures which are shot for projection to small nontheatrical audiences are indeed much less critical than pictures shot for the big screens in commercial theaters. The former may perhaps prove satisfactory if calculated by rule-of-thumb methods; for the latter much greater precision is needed if professional standards are to be met and audience discomfort and eyestrain avoided.

Mathematical analysis is needed as a tool of space control in the filming of 3-D pictures because the mental construction of a space image from data originally incorporated on two pieces of flat film bears only a remote resemblance to the human process of seeing objects "in the round" as they exist in the external world. From this analysis, as we have seen, flow important consequences relating to the design of 3-D film cameras. These may be summed up as follows.

When M is large, and f_c, in the interests of composition, is under the cameraman's control, t_c must be adjustable over a wide range, and in particular it must be capable of assuming very small values (of the order of 1 in., or even less) to make possible interesting camera effects of extreme depth range both in the studio and outdoors. Large values of t_c are essential for getting a big depth content on small screens, and for producing startling space effects on large ones.

A fixed value of t_c eliminates most of these possibilities, and greatly exaggerates the distortion of objects to which a stereo system is in any case prone. If convergence and focus are coupled, other undesirable effects make their appearance: following focus helps to negate the movement of the camera through space by bringing everything in the foreground into the plane of the screen; at the same time it becomes almost impossible to give near objects an N value much greater than unity, since they will automatically go out of focus in the attempt. But large N values — quite apart from their occasional use as stunts — are essential to the bringing of the picture close to every spectator, which is one of the outstanding advantages of the space film.

A fixed value of φ has equally little logic to support it, and it takes the control over the position of the image in space out of the hands of the cameraman and director to whom it belongs, and fixes it in accordance with some partial or erroneous theory.

By contrast, the general theory outlined in this paper — unlike the patented procedures discussed in Part III — does not prescribe any fixed camera technique or impose the use of any mechanical device. The director and cameraman should be able to make a free choice of the space effects they require the ulti-

mate audience to experience; the stereotechnician will then be able to tell them how that effect can be produced, provided that the camera equipment is sufficiently flexible and that psychological viewing factors are properly taken into account. A true parallel, therefore, would be with the science of sensitometry, which does not attempt to prescribe fixed exposure settings, but does in fact analyze the consequences of making toe and shoulder exposures, altering the developing time, using different types of emulsion, and so on.

In the same way, a valid transmission theory will enable the stereotechnician to determine what will be the geometrical form and position of the space image under all possible camera, optical printing, projection and viewing conditions. The effects of altering the space structure of the image in passing from shot to shot, as well as the space distortion in individual shots, which are revealed by this analysis, will be evaluated in the light of previous experience in seeing 3-D films. Not only will the members of the production team themselves become increasingly sensitive to the appearance of a new kind of film image, they will come to know what is and what is not effective in terms of audience response.

Already a substantial body of production experience has been built up in the last two years in the course of developing and applying the principles outlined in this paper. A dozen films have been produced which have been commercially exhibited in half as many countries and seen by audiences now nearing the 3 million mark.

If the full possibilities of the 3-D medium are to be exploited, the design of new cameras should be put in hand forthwith. Both theoretical analysis and experience point to the need of a wide flexibility in the t_c and h variables, and of a precision of adjustment and film registration equal to that which must be attained in 3-strip color cameras. By using separate 35mm films for the left- and right-eye images, and by interposing the minimum number of additional glass surfaces between scene and film, these requirements can be achieved, though there is at present only one camera in the world (the work of J. A. Norling) of adequate precision and flexibility.

Granted adequate cameras, there is no reason why films as ambitious as any now made in Hollywood should not be undertaken in the vastly more powerful 3-D medium. The knowledge thus acquired of production problems and audience response would remain of undiminished value were polarized projection to be replaced in the future by some type of integral or "free-vision" viewing screen; for though the means of separating the images may change, their appearance in space is likely to remain unaltered. For example, the parallax barriers recently classified by Kaplan in a paper of fundamental importance,[12] one and all give rise to an image geometry identical with that already analyzed in Part I for a plano-stereoscopic system.

As long as audiences will, therefore, accept for the time being the slight inconvenience of glasses — which recent European experience seems to bear out — there is no reason why major studios in the U.S. and Britain should further delay the production of at least a few dramatic films to determine whether or not they are the answer to a declining box office.

At the same time, other developments in the projection field will be under way, which will still further close the gap between the spectator and the scene, and will reinforce that sense of participation in the drama of a film which alone, perhaps, can prevent the great audiences in the motion picture theaters from dissolving away into little audiences in front of home television screens.

Acknowledgments

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Drawing in Three Dimensions for Animation and Stereoscopic Processes

By ERNEST F. HISER

Stereoscopic mathematics are far too complicated to apply easily and speedily to every point in the many drawings and cells required to obtain motion in animated films, or in a usable volume of art for commercial or lecture purposes. The following procedure was developed to allow stereo drawings to be made with a minimum of time and effort and still produce practical three-dimensional material.

In this method the artist draws to scale directly from the subject as in conventional art practices but also adds the scale distance he may be from the object, as well as the depth of subject measurements, to obtain stereoscopic effects. He is able to compute the amount of stereo depth necessary in any part of the drawing; and he is able to determine the size of the image which will appear on the screen. Stereo rules and principles as outlined in this paper do not necessarily apply to true stereoscopic mechanics, as these practices were developed only while making this simplified procedure workable. Single objects for advertising and lecture purposes drawn in stereo differ from scenic stereo art in that they are usually small in size and show considerable detail without much height, width or depth. This necessitates special consideration when preparing them for three-dimensional viewing.

Figure 1(a) shows the left (L) and right (R) eyes from above, looking to infinity with parallel lines of sight. While it is optically possible to widen these twin lines to some extent, natural visual adjustments do not depend on this ability. Stereoscopic vision is practically nonexistent beyond 1000 to 1500 ft, but from 200 ft to within a few inches of an observer the portrayal of a third dimension becomes a very noticeable accomplishment. The parallel sight lines indicated are the width of the eyes, a maximum of $2\frac{5}{8}$ in., and for all practical drawing purposes that figure is used.

Any object within the range of stereo vision will cause the eyes to converge or "toe in" just enough to focus on that object and its particular point of interest. While this point of interest is actually a point, a vertical flat plane at that point is important in this method of making stereoscopic drawings. This flat plane is to be considered as the "window-plane," and is located exactly where the

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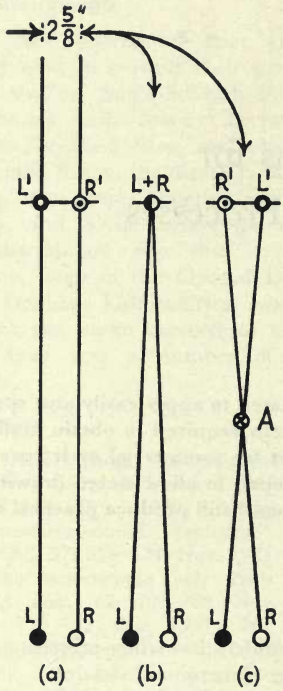

Figure 1

viewing screen will be upon projection, or where the aerial image appears upon viewing by other methods. The point of focus or interest for any object can be at any depth level within the boundaries of that object. The term "window-plane" derives from the fact that in a stereo picture all objects appear to stand out or recede from the black edge of the picture as if they were being viewed through a picture frame, or window.

Although the point of focus may be placed on any part of the subject for emphasis, a dead-center location will give the maximum overall stereoscopic effect for the subject. When the picture area includes several objects, a dead-center point of focus will provide excellent depth separation. All objects drawn to the front of the window-plane will appear nearer to the observer, while all objects drawn to the rear will appear farther away. This plane interposed into a stereo scene with the eyes set at infinity will cause the sight lines from L and R to pass through it as L^1 and R^1 ($2\frac{5}{8}$ in. apart), and the two flat drawings which constitute one stereo drawing will have their identical components separated by that scale distance on the window-plane.

In Fig. 1 (b), the lines of sight are toed in until the point of vision is focused upon the window-plane. All points on one drawing which are to appear on this plane will coincide exactly with the same points on the other drawing.

In Fig. 1 (c), the point of focus is brought forward to A, where the toe-in or crossing of the eyes causes the lines of sight to project upon the window-plane as R^1 and L^1, and in reverse order to that of infinity. As there is a limit to the toe-in effect (with the danger of obtaining ghost images), this amount should again be not more than $2\frac{5}{8}$ scale in. on the window-plane. The point where the sight lines cross, A, will always be exactly one-half the distance of the window-plane to the observer. Since the coincidal points of focus are separated by toe-in as in (b), the object focused upon will appear nearer to the observer.

In order that these measurements be made practical, it is essential that the screen size is visualized. A 40-in., 6-ft or 18-ft screen with a well placed and planned image size must be kept in mind throughout the process so that parallax on the window-plane can be computed easily for its comparative to scale likeness on both drawings.

The first drawing to be made can be designed without too much regard for stereo principles. It should have correct perspective, and the heavier lines should be drawn to the front of the subject as in accepted art practices, with the lighter lines to the rear giving an illusion of depth or roundness to the drawing. This illusion of depth in the first drawing can be intensified to advantage in this type of work. A good stereo drawing is

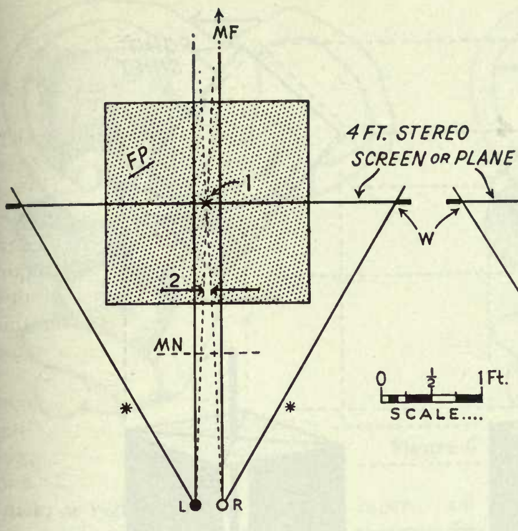

Figure 2

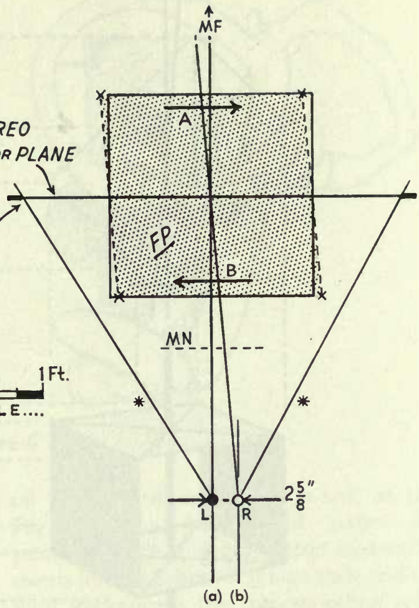

Figure 3

finished when a satisfactory delineation of the subject is obtained in the rather stiff and hard-outlined techniques peculiar to animation. In this process the first drawing is always called "L," or "the left-eye drawing" for convenience and to avoid confusion when many drawings are at hand.

Figure 2 is an extreme example with an extra-large subject, and shows the approach to the second stereo drawing while illustrating the first step in sketching a 2-ft transparent cube as it would appear in stereo from a distance of 3 ft to the artist; the focal point selection is dead center. The picture is to be shown on a 4-ft screen. The L and R eyes are placed at scale distance in scale inches apart below a cross section of the subject. (FP is the floor plan of I, the completed left-eye drawing). Vertical lines of sight to infinity show where points of vision cross the window-plane, or screen. MN and MF are the "maximum near," and the "maximum far" limits which can be drawn with the point focus in the center as indicated without causing eyestrain or ghost images. These limits increase as the distance from the artist to the subject is increased, and it is obvious that as these limits increase so does the depth of the entire picture. Infinity backgrounds may be added to assist further in depth perception. MN is exactly halfway between the window-plane and the observer, while MF is the same distance on the other side of the plane. Lines marked * are the outside limits of the picture as a whole, and run from the eyes to W — the edges of the picture or window-plane. MN and MF will always place L and R $2\frac{5}{8}$ in. apart on the window-plane.

Lines drawn from L and R through the subject area and crossed at the point of focus (1), will indicate the amount of shift (2), or line displacement, necessary for both near and far stereoscopic effects *within* the cross section.

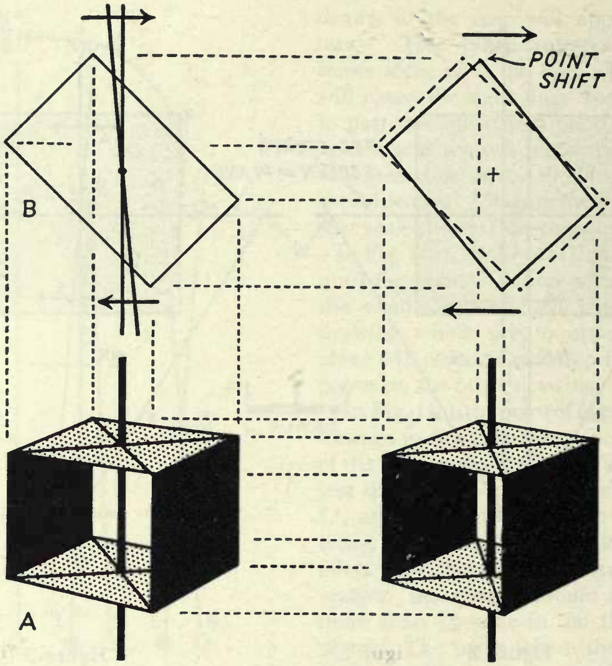

Figure 4

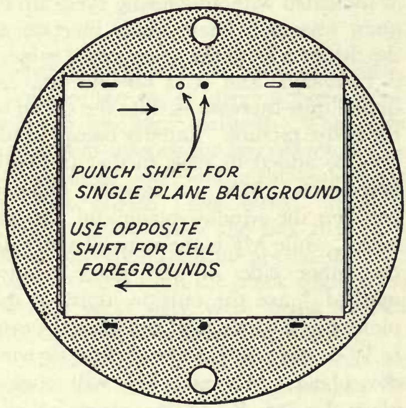

Figure 5

For further simplified operation, Fig. 3 shows that the amount of shift can be estimated quickly by a simple crossing of the L sight line at the point of focus by the R sight line. All points to the front of the focal point, as well as those at the rear are to be offset in exact proportion to the width of the shift-cross or scale, and in the direction of the corresponding arrows A and B. It is obvious that this shift will be greater or narrower in width as the distance L and R is nearer or farther away from the window-plane or focal point. Lines (a) and (b) are a reminder of the maximum separation that can be made for near and far objects.

Figure 4 illustrates a simple object with exaggerated drafting for easy visualization of the mechanics of the shift-scale, and brings the problem to completion for both L and R drawings. A is the original, or L, drawing. B is the cross section of the object with exaggerated shift-scale in place and with all major points projected over to the right where the cross section is duplicated. Point shifts are measured in accordance with the proportional widths of the shift-scale, and a

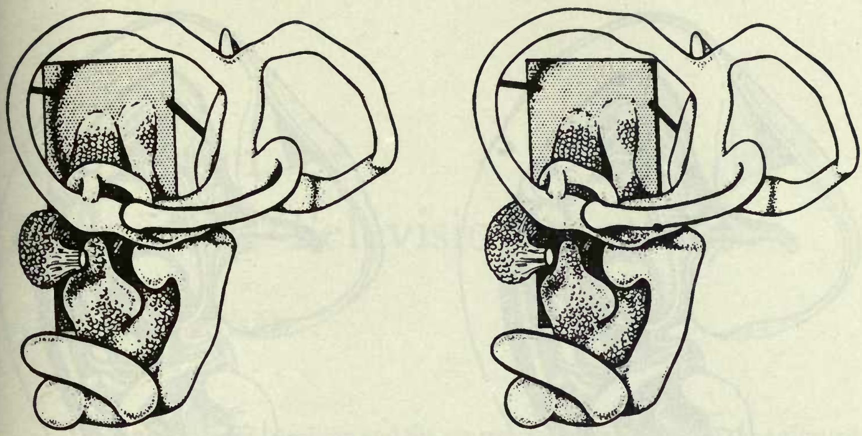

Figure 6

new, or right-eye cross section is superimposed over the L cross section. Lines are projected down from all points to complete the R stereo drawing.

Additional cross sections should be made of any part of the subject which changes contour, and from which point shifts can be measured from the shift-scale. It is possible when drawing consistently on the same distance scale (as in animation) to estimate the R shifts on either side of the point of focus by the eye alone with considerable accuracy, as soon as the near and far shifts of the scale are known for the object being drawn. Exaggerations for special emphatic effects in both near and far points of interest can be obtained by increasing or decreasing the shift-scale measurements to unbalanced amounts. The shift-scale should be drawn in perspective as in the subject when the scene is large enough to include noticeable perspective.

When a flat-plane background is to be located at any point between the back limits of the subject and infinity, only one drawing is necessary. In this case the paired L and R drawings are made on cells for use over the single-drawing background. This background will need a stereo-shift in proportion to the desired depth in the scene which is accomplished on a standard animation board, as in Fig. 5. The background paper is punched twice to proper offset measurements for the L and R image shift and is used underneath the corresponding cell to complete either the L or R assembly.

Subject parts may be labeled at their different stereo levels, and flat-plane foregrounds and details may be added in this manner to complete a scene without working on the main L and R drawings. The labels or details are drawn on cells which are double shift-punched for the correct plane, and are placed on top of the background and L or R assembly for photographing.

Figure 6 is a scientific stereo drawing made with a back mount for the subject simulating a background, a device which sometimes assists the observer in obtaining good stereo vision. Figure 7 is a drawing without a supporting background, and in this case the stereoscopic effect depends entirely upon the shift drawn in the R-eye drawing. Actually, the R drawing is the only one where depth measurement and shift are necessary. Entire animation sequences can be drawn first as for regular animated films, can be checked for timing and accuracy, and be otherwise completely finished before the R-eye series is begun.

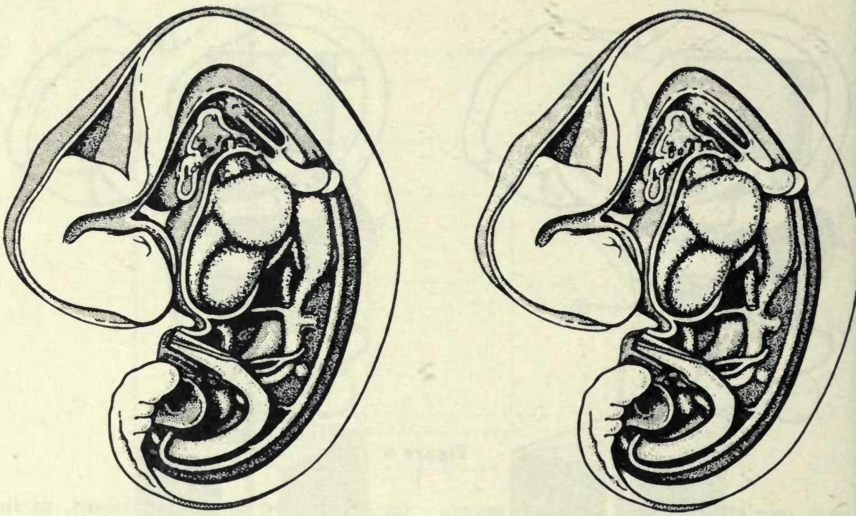

Figure 7

In cases where old two-dimensional films can be shown to advantage stereoscopically, the original drawings can be used as the entire L series.

The process of photographing the completed stereoscopic drawing assemblies depends upon the equipment available and the aims of the project. As there are several good procedures, the one currently in use will provide the method necessary to turn the completed work into practical commercial, teaching or lecture material.

Reference

1. Norman McLaren, "Stereographic animation," *Jour. SMPTE, 57:* 513–520, Dec. 1951.

Animation for Individual Television Stations

By ERNEST F. HISER

With the advent of television and the consequent increased use of the animated film for advertising, it has become necessary to devise quick and inexpensive methods for the small studio to produce such films. In this paper some simplified techniques for animation are described.

THERE IS no need to discuss or evaluate the use of animated films as an advertising or spot-announcement medium. The problem is, how can such work be produced by the average small studio art department at a time and price ratio that will allow for speed, revamping, and the visual appeal necessary for local and short-contract sponsors? Farming out films to commercial firms with their expensive production methods may be desirable but is out of the question unless the sponsor or department contemplating the work is fortunate enough to have funds warranting such productions. Simpler and cheaper methods of animation must be devised if this medium is to be utilized to full advantage.

No claim is made for extensive originality in presenting these animation techniques. This paper was primarily designed to present routines capable of producing usable film material as speedily as possible. Comparatively simple or simulated animation can be prepared after one has made a study of "stop-motion"—the basis of all animation. Throughout this paper, the term "animation" will be used to indicate all phases of stop-motion.

The staff artist does not need to be a photographer to do animation, as the photographic part of the process is mostly a fixed thing, and all camera operations necessary for the methods used are easily applied. Figure 1-(1) shows a simple camera stand with an interchangeable animation board which will work equally well under the camera and over the illuminated tracing table. Using the same board for two purposes will also eliminate error in register and layout.

It is well to remember that the *effect* of animation is the aim, rather than true animation, and that the effect processes cannot encompass some types of fluid motion. To obtain smooth motion in human and animal figures, or similar

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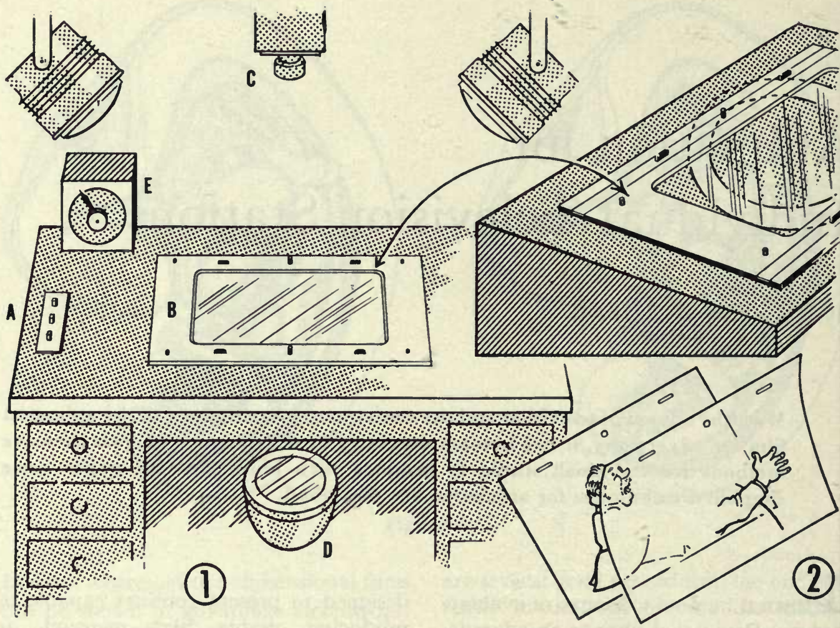

Fig. 1-(1). A, animation stand complete; B, animation board on pegs under camera (the same peg holes fit on tracing table at right which is illuminated by circular lamp); C, camera; D, lamp under animation stand for transillumination; and E, transformer for laps, fade-ins and fade-outs.

Fig. 1-(2). Method of drawing on paper with cell overlay.

complicated multiplaned objects, drawings such as those made by commercial animators will have to be approximated. Although it is possible to simplify these units to a great degree, too much simplification will produce an effect so amateurish that an entire sequence may be spoiled.

The "story" of the action, whether it be for a chart, graph or complicated pictorial delineation must first be broken down into scenes or action units as one would imagine them on the screen: titles, sound, action, etc., in proper order. Along one side of this script little sketches are made at each change of scene or action tempo. These assist in visualizing the film, and form a basis for determining the overall mechanics of timing and the animation methods to employ. This layout is called the "storyboard" (Fig. 2).

The artist "times" the action by imagining that action as taking place, even going so far as to draw rough graph lines and details as he would have them appear for each little sketch on the storyboard. With the help of a stop watch he marks the times obtained in seconds on each sketch, as well as after each legend, rest and title. The soundtrack wordage is also timed and balanced against the animation timing at this stage of the production. The artist will now be able to add "holds," or places where the action stands still, to his script while commentary wordage continues. It is seldom necessary to have continuous action throughout a sequence, in fact, holds are desirable for

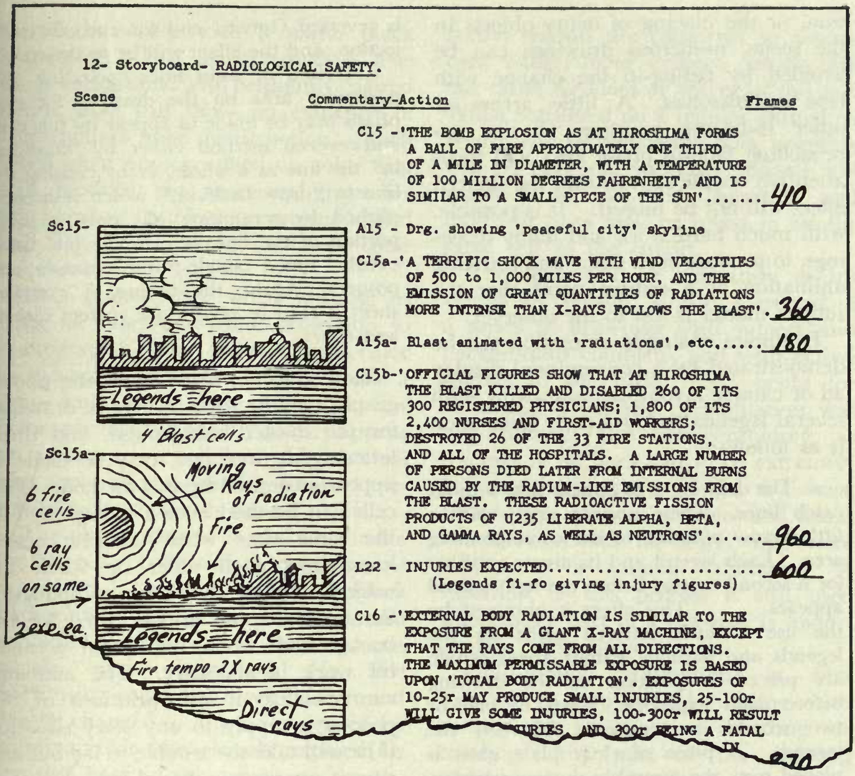

Fig. 2. The storyboard, with working data and times computed.

visual observation of scenes showing a sponsor's product, etc.

The amount of film necessary for the production can then be estimated from the total number of seconds or frames obtained. As sound film is projected at the rate of 24 frame/sec, the number of drawings required and the measurement of line displacements necessary for smooth motion can also be calculated from these timing figures. Some action speeds or drawing advances will require a two-frame exposure for each drawing, while others will use more or less exposures for smoothness of action. Caution must be used in the preparation of the exposure figures: it is very easy accidentally to clip off a few words of commentary, or to allow action to proceed too fast—or to drag along—upon the television screen.

Drawings for television should be made on paper which has a decided tone, so that unpleasant smears will not occur on the screen. On all work of this kind, pure white of any type should be used sparingly if at all. The art work should be somewhat stiff and hard, with considerable emphasis on contrast. Soft, delicate drawings may be used for background work in some instances, although detail cannot be followed easily by the viewers when this type of art is in motion.

Every phase of motion in the story need not be animated. When the action is very obvious, such as in the opening of a package, gadget manipula-

tion, or the placing of many objects in the scene, numerous drawings can be avoided by fading-in the change with laps or dissolves. A little arrow or other indicator pointing to the approaching fade-in phase area will focus attention on the spot so that the desired effect will not be missed. It is possible, with much hard work and many drawings, to produce such fancy and intricate animation at a critical point that the subject matter is lost to the observer.

Examples of simple animation can be demonstrated by a conventional display ad or catalog layout, i.e. a drawing with several legends and indicator lines upon it as follows:

a. The drawing is to appear first without catch lines. These appear singly with a little arrow pointing to the corresponding area. Each legend and its arrow vanishes for a second or two before the next legend appears. . . . This effect is obtained by the use of little lettered cards for the legends and a single cutout arrow which are placed in position on the drawing before each exposure. Rests of one or two seconds are exposed between the legends. A piece of clear plate glass is placed over the assembly during exposure to make the items lie flat and smooth. Single-frame camera work is not necessary unless the number of frames exposed must be exact.

b. The drawing is again to appear first without legends. This time the legends appear singly as before but remain in the scene once they appear. Corresponding indicator lines run from each legend directly to the point in question. In this case the lettering and lines are done on a celluloid overlay, or "cell." This cell is put in register over the drawing so that the assembly appears complete, as at the end of the sequence. The drawing is placed upside down under the camera, and the scene is photographed *backwards*, that is, by scratching off the lettering and lines from the cell one at a time with a blunt point while reading the timing figures on the storyboard in reverse order. The artist ends with only the drawing remaining under the blank cell. After this section of film has been processed it is reversed (turned end for end) for projection, and the effect will be as desired.

c. Dotted or solid lines encircling any particular area on the drawing for emphasis may be made to appear by this cell-and-reversal method either by "flashing-in" the line as a whole, or by causing the line to "draw itself in," which is accomplished by scratching out only a small portion of the line at a time while using evenly timed single-frame camera exposures. Again, the timing or exposure sheet is read in reverse for correct filming and effect.

Basic graph or chart forms and photographs may be used instead of drawings for the master background, and lines, lettering, figures, etc., may be made to appear as desired by this method. Two cells can be used over a background at the same time when separate action lines cross each other or when the subject matter is more complicated. Scratchboard can also be used for the background when additional scratch-off work is necessary. The animator can visualize many variations of this process to apply to any story situation if he will take the trouble to lay out and time a sample storyboard for a sequence which is to appear as above.

Layouts using black backgrounds are sometimes permissible for various types of work, especially when light or colored lines and lettering constitute the bulk of the copy. A good black is not always easy to get from a photographed card; and painted-out, scratched-out or covered-up lines are apt to show up as such. One way to avoid this trouble is to make the original layout in black on white paper. A *litho negative* is made of this drawing in the proper size for animation. Lines, detail and copy are drawn with transparent color as desired on this negative. It is placed in upside-down position under the camera as before, with a lamp underneath the transparency ready for transillumination. All top lamps are switched off. The lines are then painted out in reverse

storyboard order with a matte black watercolor. This process gives a true black background with brilliantly colored detail, and will show no evidence of construction upon construction. Such work when photographed on color film will produce the necessary grays for black-and-white television projection and will also provide a film for future color television.

It is a good idea when working in color for black-and-white projection to photograph a frame or two of each color in the brand of paint used and make a gray scale from these tests. As few colors photograph exactly as they appear on a card or on celluloid, this test will also serve as a guide for art work designed to be shown in color.

The above method is also invaluable for fast, easy production of line diagrams or pictorial "growths" when a black background can be used. It is also valuable for title work and designs which "draw themselves." In title work using color, the black background can be changed to any color desired by winding color film already exposed for the title back in the camera to the beginning of the title and double-exposing a piece of colored paper over the shot already made. A good paper to use for many effects in animation is artist's pastel velour, which will not reflect highlights because of its matte surface. During photographing, the transillumination lamp is, of course, turned off and the top ones turned on. This method is limited only by the animator's imagination, and will produce many color effects from any black-and-white original.

Cutout overlays may be utilized in many ways to supplant a drawing, photograph or chart, and to add interest or detail to any type of scene. These cutouts must be made accurately to register exactly with the drawing underneath. Cutouts should be made on opaque paper and have their edges blackened before use. To register correctly, cutouts are cemented to acetate cells with rubber cement, which will not cause wrinkles or waves in the cell. When registered on a regular animation board with its registering pins, assembly will be easy and successive phases will match line for line. Legends and indicator lines may be inked in on the same cell as the cutout.

The first form of animation as invented by Winsor McKay consisted of a series of drawings with subject and backgrounds complete, and with action similar to the little "flip" books for children. This type of animation was very difficult and time-consuming, as tracings of all lines had to be extremely accurate in all parts of the drawings. In this type of work the lines and detail which stood still for some time were subject to a definite "shimmy." A variation of this process is still used when every part of a drawing is undergoing a continuous change.

Fluid-motion animation is best handled in pen-and-ink outline with considerable contrast in shading or coloring. Any part of the drawing which does not move, even for a short time, should be made on a cell to eliminate work and stabilize the action. When no background is needed, the action is drawn on toned or colored sheets of paper plus the required number of work-saving cells. When the background is an inherent part of the scene, or continuous fluid motion is required over a combination layout, all action is drawn on cells. The lines and outlines are inked in on the front of the cell, and opaque color is painted within the outlines from the back, which preserves the sharpness of the inked lines and provides opacity to the cell. Action may be drawn on paper and transferred to cells as in the cutout method if desired, since the results will be the same (Fig. 1-(2)).

In animating any action the "extremes" — the first and last drawings of the scene or action phase — are sketched

first. A study of the action will then show which parts of that action will require emphasis or near-stops between the extremes. With these drawings made, the animator then has the first and last drawings as well as the major in-betweens of the contemplated action, and the assembly will appear as a series of drawings showing the major phases of a subject such as might be prepared for publication in an advertisement or article.

The storyboard will then show how much time is to be consumed between these majors. Dividing the times obtained into frames will give the proper line displacements or advance necessary on each drawing for correct and smooth action, as well as the final number of drawings required to fit the action. It is well to keep in mind the fact that the more drawings there are to be made for a certain action (involving the *least* line displacement) the smoother that action will be. If the number of drawings actually required is considerably decreased, line-displacement distances on consecutive drawings must be *increased* and a greater number of frames exposed for each drawing. These increases can easily result in a very jumpy sequence.

Slow or gradual changes are generally preferable in advertising and lecture films, and, at sound speed, a $\frac{1}{8}$-in. line advance with a two-frame exposure on a drawing which has a working field of approximately 8 × 10 in., is about the greatest advance which can be made between drawings without obtaining an irritating jumpiness. Even this does not appear too smooth at times when great contrast is encountered in art work. A $\frac{1}{4}$-in. advance with a single-frame exposure will have much smoother motion, although the tempo might be a little fast. It is always better to make a few extra drawings than to have the action pass by too quickly or shimmy badly because of excessive exposures.

After the majors and in-betweens are prepared the drawings are checked for all lines and components which will stand still for any length of time during the action. These lines are drawn on cells for stabilization and elimination of shimmy. Although regular commercial animators use a complicated three-cell arrangement it is seldom necessary to go beyond one cell for simplified advertising and spot films. When even one cell is used over a background or for work-saving reasons, it will be necessary to expose all drawings of that series through the same number of blank cells before and after the cells are used because of the extra tone imparted to a scene by any cell overlay.

After the cells are made, the extremes, majors and in-betweens on paper are inked in (minus the lines on the cells). In finishing the in-betweens it is not necessary in fairly rapid action to obtain the same degree of exactness in draftsmanship as on the majors, although the line displacements must be accurate.

Each drawing is then marked as to consecutive number in the scene, number of exposures required, the number of the cell which must accompany it, and any other data considered important to the animator.

To eliminate excessive background area, or to localize action or interest, a foreground can be made of colored velour paper with a round or otherwise suitable opening in it for the action to show through. This foreground is placed over the drawing assembly on the registering pins before exposure of the scene.

The above basic production methods are as near to actual commercial animation as the television animator needs to go for the production of ordinary local film needs, and by using one or all of the above — even in one sequence when they will blend together — much valuable material can be designed. The effect or presentation of the subject is all that matters; the manner of obtain-

ing that effect is secondary as long as the methods employed do not result in a visual hodgepodge of artistic media without advertising or story value. Once more, the entire effort depends upon the design of the storyboard — the blueprint of the production. If the storyboard has been carefully drafted with full regard to the story, and timed with a view to good presentation, an overall technique will become apparent which includes one or more of the above processes of simplified animation. The method using the least amount of art work should be selected whenever possible, as in many cases the simpler technique will present the subject more graphically than will the complicated one.

Animation should only be used when the subject cannot be presented by regular photography, or when a new method of approach, unusual effects, or the presence of artistic values can play an important part in the instructive aspects of the advertisement or story. Animation should also be used as an adjunct rather than as the principle illustrative medium unless the entire subject benefits by graphic animated pictorialization.

X-ray Motion Picture Techniques Employed in Medical Diagnosis and Research

By S. A. WEINBERG, J. S. WATSON, Jr., and G. H. RAMSEY

With Appendix by W. E. SCHADE

X-ray motion picture techniques are reviewed with attention to relative exposure requirements and ability to record detail. Direct cineradiography on full-scale screen-films provides the best reproduction of detail but does not at present reach true motion picture speeds. Cinefluorography is the most flexible and least expensive of the traditional methods. Because of harmful effects of radiation cinefluorographic examinations of human subjects must generally be limited to a relatively few seconds. The length of examinations can be much prolonged with the help of screen image intensification. Unfortunately the x-ray motion pictures made by kinescope recording are not yet satisfactory from the point of view of detail.

THERE ARE a number of ways of making x-ray motion pictures, each one of which has its special virtues and limitations:

1. Successive frames of film are exposed directly to the x-rays which have passed through the subject.
2. Instead of being exposed directly to x-rays, each frame of double-coated film is compressed at the moment of exposure between a pair of fluorescent intensifying screens. Excited by x-rays, the screens emit violet and blue light, thus exposing the film.
3. A fluorescent screen is set up perpendicular to the x-ray beam as in fluoroscopy. The image formed on the near side of the screen is copied by a motion picture camera to a much reduced scale.
4. The screen image is picked up by a television camera, and a kinescope recording is made of the action. This method is still in the experimental stage.

Direct Cineradiography Without Intensifying Screens

Methods 1 and 2 are generally referred to as direct or full-scale cineradi-

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Presented on May 2, 1951, at the Society's Convention at New York, by S. A. Weinberg, J. S. Watson, Jr., and G. H. Ramsey, Dept. of Radiology, University of Rochester School of Medicine and Dentistry, 260 Crittenden Blvd., Rochester 20, N.Y. This investigation was supported in part by a research grant from the National Heart Institute of the National Institutes of Health, Public Health Service. The appendix was contributed in June 1952 by W. E. Schade, Hawk-Eye Works, Eastman Kodak Co., Rochester, N.Y.

ography. In both cases the shadow image on the film is a little larger than the subject; and in this respect the methods are alike. There is, however, a striking difference between them in the matter of photographic speed. Mainly because of the poor absorption of hard x-rays by the film emulsion, an examination recorded on single-coated film without screens, at diagnostic kilovoltage levels, may require 25 or 50 times as much x-ray intensity as a similar examination recorded with the aid of intensifying screens. Method 1 is, in fact, so "slow" that its use is confined to small, easily penetrable subjects of thin cross section. The subject, a worm or insect,[1] the thorax or abdomen of a mouse,[2] is positioned in front of the aperture of a 35mm camera, and the x-ray beam is directed through the subject to the film. During the pulldown phase of the camera the film must be protected from x-ray fogging, either by reinforcing the shutter with lead or by interrupting the primary circuit of the x-ray generator.[3] It so happens that the ability of the unaided film emulsion to resolve fine detail is relatively very good. This is fortunate, because the significant detail of small subjects approaches the microscopic.

Direct Cineradiography With Intensifying Screens

With the aid of intensifying screens direct cineradiography becomes a much "faster" technique and can be applied to much larger and denser subjects. The size of the film frame may be anywhere from 5 by 5 in. to 12 by 15 in., the latter size being large enough to include an adult chest. When properly exposed, the so-called screen-films are recognized models of radiographic quality and would appear at first glance to be an ideal, if rather expensive, medium for making x-ray motion pictures of human subjects. Unfortunately it is not easy to impart rapid intermittent motion to large strips of film. Machines have been designed with the hope of making 12 or 16 pictures/sec, but few, if any, of them can be counted on to function at more than 4 or 5 pictures/sec without frequent breakdowns.[4] The necessity for sandwiching each frame of film closely between fragile screens at the instant of exposure makes the problem doubly difficult. Both film and screens pick up multiple scratches, dust and fragments collect at the aperture, and, worst of all, poor contact between screens and film results in grossly unsharp pictures.

The most successful attempts at full-scale cineradiography at true motion picture speeds have been made on continuously moving 15-in roll film exposed to extremely brief pulses of radiation. The single-coated film passes over an idle roller surfaced with a low-lag phosphor, the film being thus exposed in contact with what amounts to a single intensifying screen. With an experimental condenser discharge apparatus, as many as 100 exposures/sec have been made in this way.

As a rule, however, the motion studies made by method 2 are not true x-ray motion pictures, but simply rapid serial x-rays exposed at from 1 to 5 pictures/sec. Rapid serial x-rays have been much in demand in the past few years for making contrast studies of various parts of the circulatory system. The negatives are read as stills, although it is perfectly possible to copy them in sequence on motion picture film, and by repeating each negative frame three or four times on the print, to turn out a rather jerky motion picture.[5]

Cinefluorography

The great majority of true x-ray motion pictures are made by method 3, generally known as cinefluorography or indirect cineradiography. Here we have an economical and flexible technique for examining subjects of medium and large size at camera speeds up to 120 frames/sec. The faults of the method are, first, a less favorable exposure factor

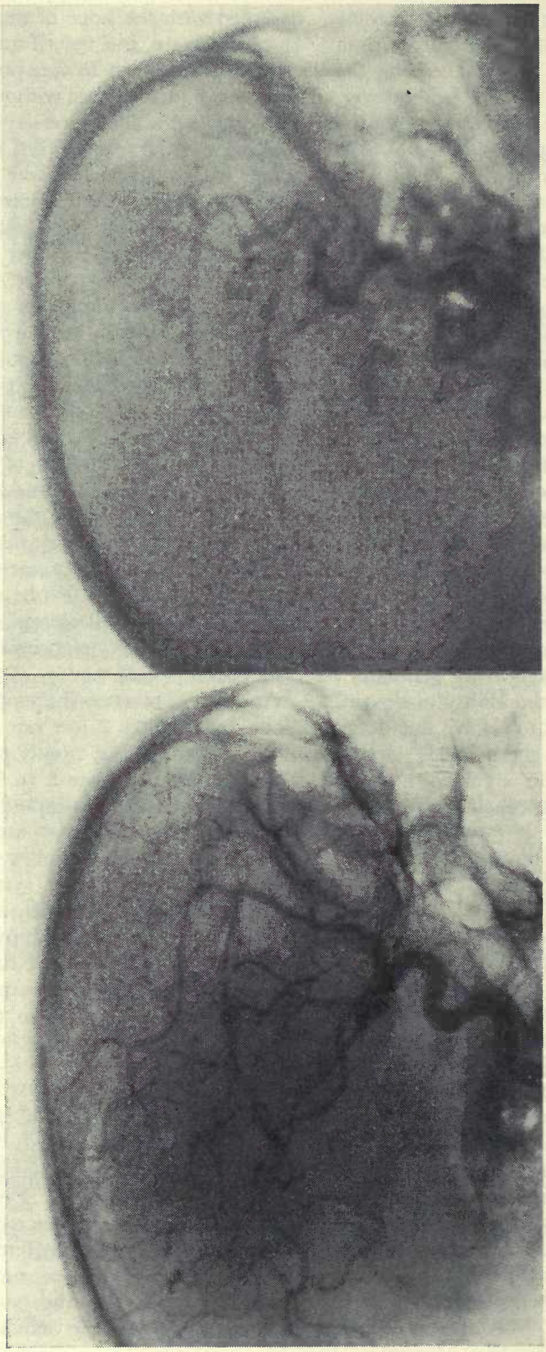

Fig. 1. Contrast studies of the cerebral circulation: left, contact print of a full-scale screen-film; right, enlarged 35mm frame from a 5-sec cinefluorographic record made with an f/0.85 lens and Patterson E2 screen at 60 frames/sec. Many of the smaller vessels which can be plainly seen on the full-scale film are only faintly perceptible on the 35mm film.

than that of direct cineradiography with screens, and second, a considerably greater degree of inherent unsharpness, as can be seen from the comparative figures given in Table I. It must also be admitted that the single-coated motion picture film is inferior in contrast to double-coated screen-film. About the only remedy for this condition is the frequent use of a stationary grid to increase contrast by reducing scatter.

Table I. Exposure and Unsharpness* Characteristics of X-ray Motion Picture Techniques

Method	Relative exposure requirement	Unsharpness* or blur, mm
1. Direct cineradiography (without screens)	25.0	0.05
2. Direct cineradiography (medium speed screens). .	1.0	0.3
12 by 16 in. E2 screen, *f*/0.85 lens, ortho film	2.0	6.0
3. 35mm cinefluorography 10 by 13 in. E2 screen, *f*/1.5 lens, ortho film	8.0	3.0
4½ by 6 in. D screen, *f*/1.5 lens, ortho film	16.0	1.5

* The unsharpness values listed above are offered as rough estimates and may contain a fairly large error. It is particularly difficult to give a satisfactory overall unsharpness value for the 35mm frame because of the wide difference between lens performance at the edge and in the center. For a constructive criticism of traditional sharpness and resolution measurements, see the recent paper by Higgins and Jones.[6]

If sufficient radiation could be brought to bear, it would no doubt be possible to make 35mm cinefluorographic records displaying nearly as much subject detail as 35mm reduction prints from full-scale screen-films. There is, however, an upper limit to the amount of continuous or near-continuous radiation that can be provided by the x-ray machine, and this limit must be further reduced when dealing with human subjects. Subject thickness, camera speed and length of examination in seconds must all be taken into account in budgeting permissible radiation, often leaving little room for the niceties of good copying. The desirably sharp tungstate intensifying screen, to which routine screen-films owe much of their excellent definition, is replaced in cinefluorography of adult human subjects by a faster, less sharp screen coated with relatively coarse crystals of zinc cadmium sulfide. Then the blurred image formed on the unsharp screen is copied, blurs and all, by an ultrafast lens (definitely not a process lens) which in turn contributes additional blur and flare of its own.

As an illustration of what happens to fine subject detail under these extreme conditions we have reproduced side by side in Fig. 1 a full-scale screen-film and an enlarged 35mm frame taken from a cinefluorographic record. In this particular case the improvement of 35mm definition, which could have been obtained by using a slower, better-corrected lens or a slower, sharper screen, was sacrificed in favor of a relatively high camera speed. Figure 2 shows the improvement of definition which results from using a sharp screen in close-up views. Curiously enough we have been unable to obtain any appreciable increase in sharpness by substituting a finer-grain film for the fast green-sensitive ortho film commonly used in cinefluorography.

The *f*/0.85 lens referred to in Table I is the 55-mm Zeiss R-Biotar originally designed for 16mm film, but used, for want of anything better, on several 35mm cinefluorographic units including our own (Fig. 3). With this lens at full aperture, definition in the corners of the 35mm frame is frankly ter-

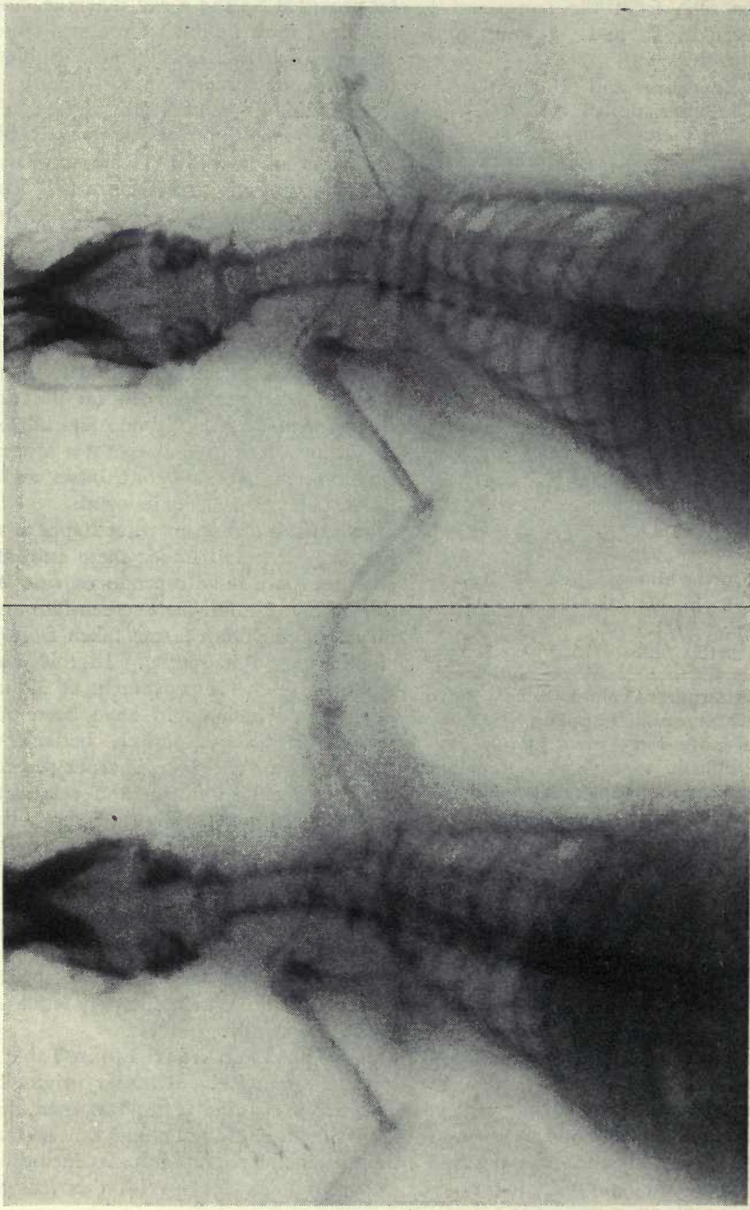

Fig. 2. Enlarged 35mm views of a rat: left, made with E2 screen; right, made with medium speed intensifying screen. Same lens and film were used for both. The right required 5 times as much exposure as the left.

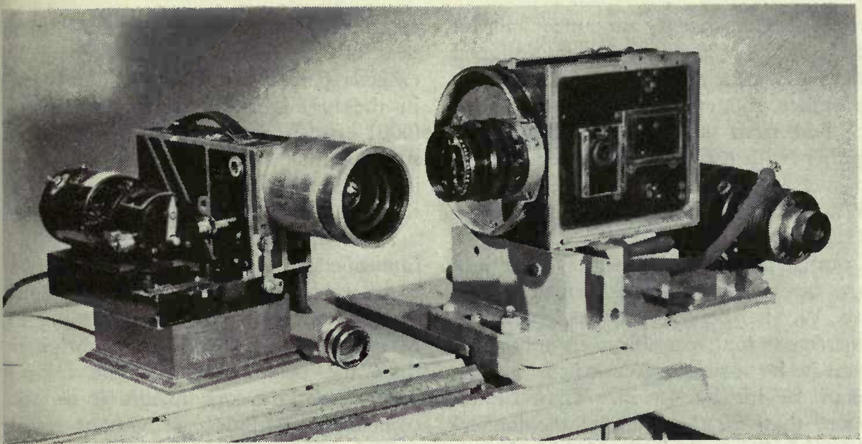

Fig. 3. Left, Kodak f/0.81 43-mm focal length lens mounted on Cine Kodak Special. A popular f/1.5 lens is shown below for comparison. Right, Zeiss R-Biotar f/0.85 55-mm focal length lens mounted on 35mm camera.

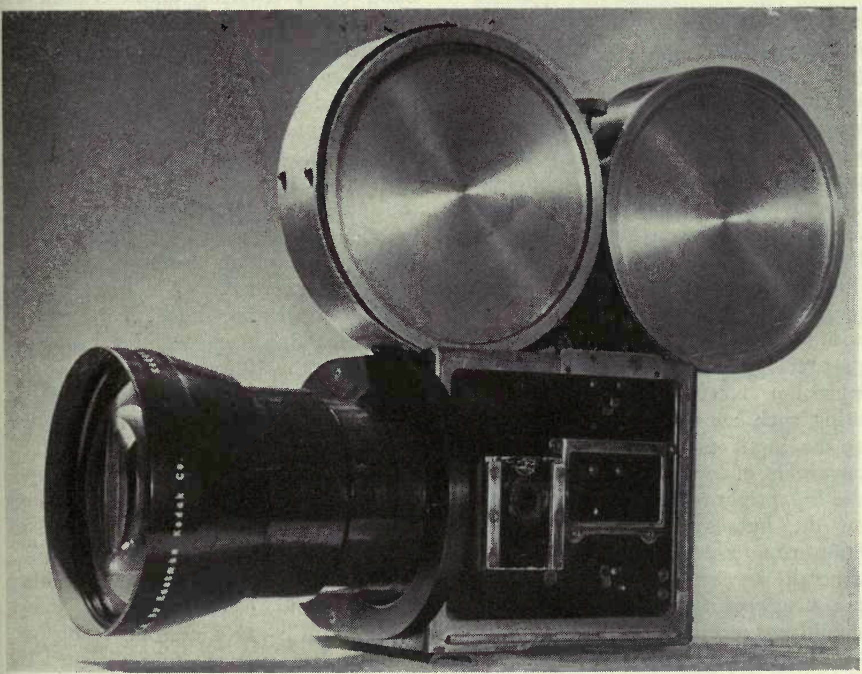

Fig. 4. New Kodak f/0.75 Fluro Ektar Lens designed for cinefluorography at a magnification of 1:16 (U.S. Patent 2,604,013).

rible. The recent announcement of two new refracting lenses designed specifically for 35mm cinefluorography promises better definition than can be had from the 55-mm R-Biotar, together with an increase rather than a decrease of speed. The lenses are the Wray 65-mm $f/0.71$ and the Kodak 110-mm Fluro Ektar $f/0.75$ (Fig. 4). Constructional details of the latter lens are described in the appended article by W. E. Schade. Both lenses are corrected for magnification of 1:16, that is, for a screen area a little smaller than 12 in. by 16 in. They should more than fill the place of the longer-focus Leitz and Zeiss $f/0.85$ lenses, manufactured at one time for 35mm cinefluorography, but unobtainable since 1940.

X-ray Motion Pictures by Kinescope Recording

The fourth method of making x-ray motion pictures has emerged as a by-product of recent experiments in fluoroscopic screen intensification. Of the various image tubes and other devices which have been developed for this purpose the only one at present adaptable to motion picture work appears to be the Johns Hopkins apparatus demonstrated by Morgan[7] in 1950. In Morgan's intensifier the fluoroscopic image is picked up by a television camera fitted with an $f/0.7$ Schmidt optical system of the "folded" type sometimes seen in television receivers. The reason for using such an extremely fast objective at the input end of the television apparatus is, of course, to make the most of the low brightness conditions prevailing on the fluorescent screen at average fluoroscopic x-ray intensities. It is now generally agreed that during fluoroscopy the near point on the subject's skin should not receive more than 10 r/min, a dosage rate frequently reduced to 3 r/min or less by increasing filtration of the x-ray beam and using higher peak voltage across the x-ray tube. At these comparatively low intensities the brightness of the fluoroscopic image rarely exceeds 0.03 ft-mL (foot-millilamberts) in the highlights, and may fall below 0.001 ft-mL in the shadows. That such an image can be picked up at all indicates the remarkable sensitivity of the image orthicon tube.

As it appears on the kinescope, the intensified image of the subject is said to have an average brightness of about 3 ft-mL, and is therefore, according to Morgan, from 300 to 3000 times brighter than the original fluoroscopic image. Like other kinescope images it can be copied at 30 frames/sec without resort to high-contrast film or lenses of aperture greater than $f/1.5$.

By way of demonstrating the motion picture possibilities of his intensifier, Morgan has made a kinescope recording of a barium enema examination of a child of 7, covering about 3 min of action,[7] during which time the subject is said to have received a total skin dose of only 20 r. If it were attempted to record a similar examination by routine cinefluorography ($f/0.85$ lens, E2 screen, stationary grid to reduce scatter, camera speed of 30 frames/sec), the total dose of 20 r would be reached in about 10 sec; in other words, only about 1/18 of the 3-min examination could be recorded. Of course, by reducing camera speed to 7.5 frames/sec (and repeating each negative frame on the print) the 10 sec of recorded action could be stretched to 40. Indeed, it would be possible by substituting the Fluro Ektar $f/0.75$ lens for the $f/0.85$ R-Biotar to prolong the take to 50 sec, but even so a more than three-fold advantage would remain with the kinescope record.

As can be imagined from the number of glass and electron optical stages involved in x-ray kinescope recording, the motion picture films made by method 4 are not at present satisfactory from the point of view of detail. To what extent this condition can be im-

proved remains to be seen. Certainly there is enough demand for better fluoroscopy, not to mention better image tubes and better television, to insure that the problem will not be neglected.

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Appendix: A New Kodak f/0.75 Fluro Ektar Lens*

By W. E. Schade

The new Kodak Fluro Ektar lens, *f*/0.75 of focal length 110 mm designed for 35mm cinefluorography at a magnification of 1:16, can be described as an extended modification of the classical example of simplicity, the Cooke triplet, to which a negative field-flattening element located near the focal plane has been added. Alternatively, the system could be regarded as a modified Cooke triplet to which a telephoto system has been attached.

However, since simplicity and the application of a field-flattening element have been the leading motives in the design of the lens, the following detailed explanations will pertain to the first description.

The *f*/0.75 Fluro Ektar lens consists of seven glass elements, two of which are made of the new high-index glasses developed and manufactured by Eastman Kodak Co. (Fig. 5).

The first two elements (1 and 2) are of collective power. These are followed by a hyperchromatic component of dispersive power. The negative element (3) of this component is made of a highly dispersing flint glass, whereas the other element (4) of this component consists of one of the new high-index glasses mentioned above. The properties of these two glasses, namely, nearly equal high indices of refraction for the D line, but widely differing dispersions, have made it possible to simplify the achromatization of the new lens.

Elements 5 and 6 are again of collective power, element 6 being made of one of the new high-index glasses.

The arrangement of these six elements, as shown in Fig. 5 produces a focal length of 106.4 mm and the marginal ray emerges at an aperture of *f*/0.64.

Finally, the field-flattening element (7) of dispersive power, located near the focal plane, then extends the focal length to 110 mm and reduces the aperture to *f*/0.75 as required.

The results of this relatively simple design are such that the lens will render

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The Appendix was contributed in June 1952 by W. E. Schade, Hawk-Eye Works, Eastman Kodak Company, Rochester, N. Y.

* U.S. Patent, 2,604,013, Aug. 8, 1951.

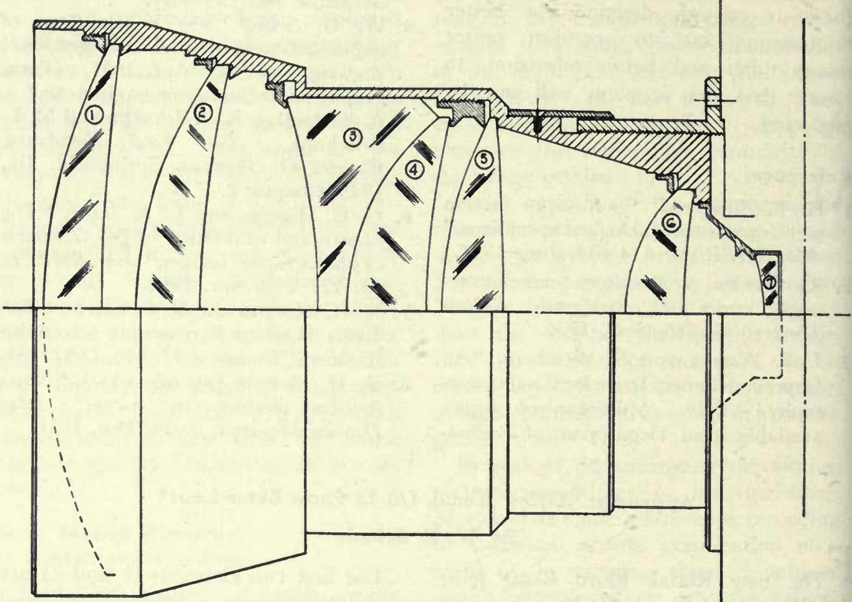

Fig. 5. Cross section of Kodak f/0.75 Fluro Ektar Lens of 110-mm focal length designed for 35mm cinefluorography (U. S. Patent 2,604,013).

highly satisfactory performance in many applications. The spherical aberrations have been reduced to an extreme minimum. Astigmatism and curvature of field are practically eliminated and the distortion (barrel) is negligible. The color corrections, longitudinal as well as lateral, are also fulfilled.

The dimensions of the system at a magnification of 1:16 are as follows:

Distance from screen to image plane . . . . . 2023.1 mm
Object distance (from screen to first surface of lens . . . . 1807.8 mm
Image distance (from last surface to image plane). 7.3 mm
Length of lens (from first to last surface) . . . . 208.0 mm
Diameter of front aperture . 143.2 mm

Since preliminary tests have proved the exceptionally satisfactory performance of the lens, it is anticipated many applications for it will be found in other fields.

A Precision Color Temperature Meter for Tungsten Illumination

By G. H. DAWSON, D. E. GRANT and H. F. OTT

A precision color temperature meter utilizing red and blue filters is described. A special logarithmic diaphragm largely eliminates undesirable effects of nonuniform response over the cell area and aids accurate setting of the red filter standard at high intensities.

For most visual or photographic purposes extremely accurate measurements of color temperature are not necessary. In the film industry, however, color films must be evaluated carefully to determine specifications which will, under proper conditions of exposure and processing, result in uniformly good color balance. Consequently, to remove test variability as much as possible, it is necessary to know and control within relatively close limits the color temperature of the tungsten lamps. A red–blue ratio is used as an index of color temperature since the radiation from a tungsten lamp follows closely the spectral energy distribution of a blackbody.

It was found that the variability within available meters was greater than the allowable tolerances of the tungsten source itself for testing purposes. Such a relatively high instrument variability would not assure a sufficiently reliable determination of color temperature.

Variability in most commercially available meters can be attributed to:

1. Differential diffusion of blue and red light and vignetting. These errors are most serious when the light is off axis or when an extended source is used.
2. Nonuniformities in response from one area to another of the cell, giving different effective color temperature readings at different intensities of illumination.
3. Difficulties in adjusting the instrument to the red filter standard at high intensities where the aperture over the cell is small and its area is changing rapidly when a direct linear diaphragm is used.
4. A trigger arrangement for shifting filters which moves the entire instrument when actuated.

Description

An improved color temperature meter, Fig. 1, utilizing red and blue filters has been designed by the authors to give the needed precision. Most important to

A contribution submitted July 21, 1952, by G. E. Dawson, D. E. Grant and H. F. Ott, Color Control Div., Eastman Kodak Co., Rochester 4, N.Y.

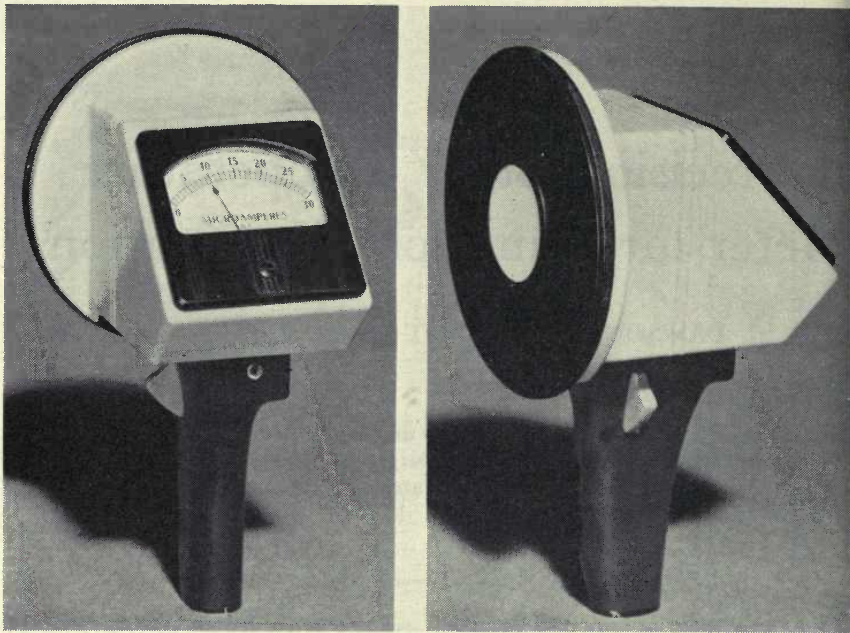

Fig. 1. Color Temperature Meter.

the increased precision is a specially designed diaphragm which allows incident light to be distributed over the cell surface at either high or low intensity.

The essential elements of the instrument, labeled to correspond to Fig. 2, are:

- a. The diffuser
- c. The special diaphragm
- b, d. Filters
- f. Trigger arrangement for switching filters
- e. Photronic cell
- i. Meter
- g, h. Handle, including tripod socket

In use, the color temperature meter is pointed directly at the source to be measured and the diaphragm ring rotated until a standard reading is obtained on the microammeter through the red filter. The trigger is then depressed and a second reading is obtained through the blue filter. The color temperature of the source can then be read from a calibration curve. A scale could be inscribed on the microammeter reading directly in color temperature.

Diffuser, Cell and Meter

To keep the angular acceptance large, as well as to maintain accuracy of the instrument, an opal diffuser was put at the extreme front of the instrument. The metal parts, other than the diaphragm, were arranged so they could cause no shadowing of the cell. In addition, the diffuser-to-cell distance was made as small as possible. The diffuser chosen was an opalized cellulose acetate on glass support. To remove any effects of the blue–red diffusion differential of the opalized glass, a pale blue filter was placed between the diffuser and the diaphragm. Areas of the filter are cut away so that it gives maximum compensation when the dia-

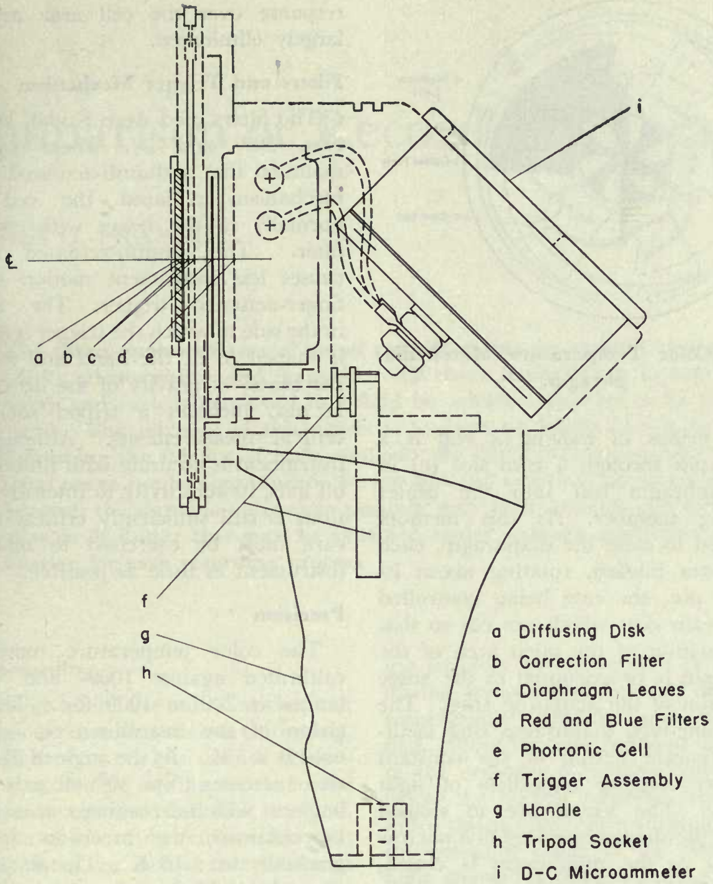

Fig. 2. Schematic side view of Color Temperature Meter.

phragm openings are large, but none when they are small.

The cell used in the instrument is a Type 3RR Weston Photronic Cell especially selected for low fatigue at both ends of the visual spectrum. The meter is Model 731 Weston 0 to 30 microammeter.

Diaphragm

The special diaphragm (Fig. 3) utilizes six leaves (a), three on each side of a thin center plate (b) which by rotation causes the leaves to move over the aperture or away from it. The leaves and actuating disk are between two outer plates. These plates support the pins on which the pivot ends of the diaphragm leaves can rotate. The diaphragm leaves have long, narrow tongues which at full open position extend across the circular diaphragm opening dividing it into six pie-shaped openings. Since the support pins for the leaves are spaced at 60° intervals alternately in one support plate then the other, the tongue of one leaf at full open aperture overlays the tongue of a leaf on the opposite side of the actuator.

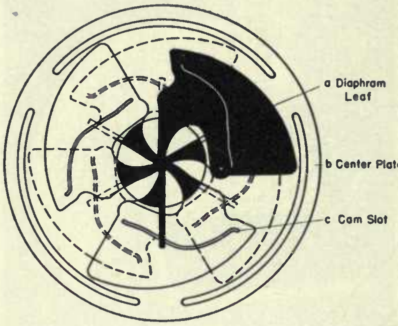

Fig. 3. Color Temperature Meter diaphragm.

The means of moving a leaf is a headed pin through a cam slot (c) in the diaphragm leaf into the center actuating member. As this member is rotated to close the diaphragm, each leaf moves inward, rotating about its support pin, the rate being controlled by the cam slots which are cut so that the logarithm of the open area of the diaphragm is proportional to the angle of rotation of the actuating ring. The logarithmic-type diaphragm ring facilitates accurate setting of the constant red filter reading regardless of light intensity. The leaves are so shaped that the pie-shaped openings first narrow abruptly as the diaphragm is closed, then gradually change shape to form six equally-spaced diminishing cat-eyes. The undesirable effects of nonuniform response over the cell area are thus largely eliminated.

Filters and Trigger Mechanism

The filters used were Kodak Wratten Nos. 38A and 29. These were so mounted that a thumb-actuated trigger mechanism replaced the red filter normally in the beam with the blue filter. The thumb-actuated trigger causes less instrument motion than a finger-actuated trigger. The handle, in the side of which the trigger is located, is shaped to fit the hand and is under the center of gravity of the instrument. It also includes a tripod socket for critical measurements. Although the instrument is accurate with illumination off axis, its sensitivity to intensity variations is still sufficiently critical so that care must be exercised to move the instrument as little as possible.

Precision

The color temperature meter was calibrated against 1000- and 1500-w lamps at 200 to 1000 ft-c. The precision of the instrument as normally used is ±5 K. As the angle of illumination increases from 30° off axis to the angle at which a reading can no longer be obtained, the precision decreases gradually to ±10 K. The accuracy is dependent chiefly upon the validity of the calibrations of the lamps used as standards.

Comparison of Recording Processes

By JOHN G. FRAYNE

The three common forms of sound recording may be classed as mechanical (disk), photographic and magnetic. All three methods are in common use today and each is employed in a field for which it appears to be peculiarly fitted. The purpose of this article is to examine briefly the factors which determine the fidelity of each method. By fidelity we mean how true the tonal range can be reproduced, the amount and nature of harmonic distortion present, the signal-to-noise ratio possible with each method, and the amount of wow or flutter that may be expected under average conditions of reproduction for each recording process.

Disk Recording

Although there are other methods of mechanical recording, such as embossing, we shall confine our discussions on mechanical recording in this article to the well-known circular flat disk method. This type of recording remains the most popular form for home entertainment and is widely used in transcription radio programs. One characteristic that differentiates disk recording from the other methods is the comparatively higher mass of the moving parts involved in making and reproducing the record. The disk material must actually be cut with a stylus having a high degree of stiffness and a comparatively high mass. Likewise on reproduction, disk recording involves the movement of a reproducing stylus which in itself must have considerable stiffness and mass. In disk recording, the resonant frequency of the recorder is usually considerably below the highest recorded frequencies. Since this necessitates recording through the resonant range of the recorder, a high degree of damping must be employed to remove the resulting resonant peak. This damping, whether supplied by mechanical means or electromagnetically through some sort of feedback system, results in a velocity of the recording stylus which is constant and independent of the frequency for a constant applied force. This type of recording is known as constant velocity and with the addition of pre-emphasis in the recording circuit is widely used in cutting present-day high-quality records.

Since the amplitude of the cut for a constant applied force is inversely proportional to the frequency in a constant velocity recorder, it is customary to record the lower frequencies or longer

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wavelengths on a more nearly constant amplitude basis. This limits the amplitude of the cut at the lower frequencies. The frequency at which the change-over is made is usually referred to as the crossover point. In cheaper recorders, this presents no problem, but in the higher-quality feedback-type recorders, this has to be done by appropriate recording equalization. With the best type of feedback cutters, good records may be recorded out to 12–15 kc, whereas on the cheaper types 5 or 6 kc is a desirable upper limit. When a constant velocity record is reproduced with a variable reluctance type of reproducer, a constant voltage results. For those parts of the spectrum cut at constant amplitude, reproducing equalization complementary to that used in recording must be used.

Like all recording media, disk recording is subject to its own peculiar types of distortion. One of the most common forms of disk distortion is brought about by the fact that a sinusoidal wave cut into the record must be tracked in reproduction by a stylus of finite radius of curvature. It is obvious that at short wavelengths it is impossible under such conditions to reproduce a true sinusoidal response. Instead, a series of poids result which, in the case of the more common lateral type of disk recording, produce odd-order harmonic distortions. Since the wavelength for any given frequency diminishes as the groove diameter of the disk is reduced, such distortion increases rapidly with diminishing diameter for any given impressed frequency. This has been studied in detail by Pierce and Hunt and they show, for example, that in $33\frac{1}{3}$-rpm records, distortion at 5000 cycles may amount to as much as 30% for an 8-in. diameter, dropping to as low as 2% for a 16-in. diameter. Similarly for 78-rpm records for the same frequency, distortion may amount to 20% for a 4-in. diameter and drop to approximately 1% for a 12-in. diameter. It is this factor which limits the effective inner diameter on $33\frac{1}{3}$-rpm microgroove records to 5 in. and on 45 rpm to $3\frac{3}{4}$ in. Accompanying this increasing distortion as the groove diameter is reduced is a corresponding loss in high-frequency response. This may be corrected to a certain degree by introducing variable equalization in recording, increasing the high-frequency input to the cutter as the groove diameter is reduced. While this may correct for high-frequency response, it only adds to the distortion resulting at the higher inputs.

Another form of distortion in reproducing from disk records is known as tracking distortion. This is brought about by the fact that since the reproducer is supported by a pivoted arm, the angle which the axis of the stylus makes with the groove is constantly changing as the reproducer moves across the record. This form of distortion is very complicated and results in the generation of both even and odd harmonics. This tracking error can be reduced to a minimum by proper design of the reproducing arm.

The commonly used expression "wow" to denote low-frequency speed variations in sound reproduction had its origin in the once-per-revolution speed variation (wow) of cheap disk turntables. At 78 rpm this corresponds to a frequency of 1.3 cycles/sec, a rate at which the ear is extraordinarily sensitive to pitch changes. This low-frequency rate is a difficult one to correct in a mechanical system without resort to very expensive and accurate drive systems which are completely beyond the range of the home pocketbook. The problem is further aggravated by the provision for three speeds in many turntables, each of which may call for somewhat different corrective mechanical filtering. In the professional field, the problem of wow has been largely overcome and flutter less than 0.1% may be attained.

Another factor which has limited high fidelity in disk reproduction has been the so-called needle scratch. This has been accented by the use of the older-type shellac records carrying an abrasive for grinding the steel reproducer needle to match the groove. This condition has been greatly improved in recent years by the adoption of improved pressing materials such as acetate or Vinylite and the wide adoption of permanent-type needles. For home use, a signal-to-noise ratio of the order of 40 db is probably adequate, but for professional use this should be improved to at least 50 db. A further improvement in signal-to-noise ratio is the recent adoption of the so-called hot stylus technique in recording. This method usually results in an improved signal-to-noise ratio especially at the inside area of the disk. Simultaneously, it appears to result in improved high-frequency response.

When one considers the mechanical nature of disk recording and reproduction and the fact that a plastic with its cold flow and general instability has to be employed, the resulting fidelity in modern disk recording may be considered a triumph of research in industrial design and manufacture. When one further takes note of the various processes which are followed in going from an original acetate cut record through the plating and stamping processes, one is further impressed at the really excellent job that can be done in modern disk recording.

Photographic Recording

Under ideal conditions of recording, processing and reproduction, modern photographic recording offers a medium of high-fidelity sound reproduction the equal, if not superior, to that of any other method. Two well-known methods — variable-density and variable-area — are in wide use in photographic recording. With accurate control of film processing, extremely high fidelity records may be obtained for both variable-density and variable-area methods. In the professional 35mm field, such controls are successfully used with a resulting high-quality product. In the lower-cost 16mm field, it is a matter of regret that much improvement is still awaited in this regard. Over the years since photographic recording was first introduced, there has been a vast improvement in the type of photographic emulsions suitable for both density and area recordings. Recording devices and light-modulating systems have been brought to a point of near perfection, and the general improvement in the electronic art has contributed to practically distortion-free film and reproducing systems.

A method of reducing background noise unique to photographic recording is the universal use of bias or noise-reduction recording in which the average transparency of the sound track varies with the envelope of the sound waveform. This results in a minimum of film grain noise and photocell hiss for the low-level passages and automatically permits a rise in these unwanted noises as the signal amplitude increases.

The most difficult problem to overcome in photographic recording has been the development of high-quality transport of the film past the point of optical translation. The earlier film recorders were subject to much wow and flutter with disturbing rates varying all the way from 1 cycle/sec to 96 cycles/sec, the latter corresponding to the sprocket-hole frequency of 35mm film. As a result of much research into the nature of flutter, improved designs of professional 35mm recorders and reproducers have been introduced in recent years which are remarkably free from flutter. Today, a photographic recorder with a total flutter content exceeding 0.1% would have difficulty finding any market. In 16mm photographic recording, due to the slower speed employed, it is more difficult to

secure equally good film movement. This is only too obvious in the reproduction of many 16mm sound tracks heard over television programs. As a consequence, high-quality 16mm film recorders should call for more careful design and construction than the more professional 35mm types. The contrary, however, has usually been the result, due to the poorer economic status of 16mm. The same comment holds even more true for 16mm reproducers. Instead of the sturdy professional-type 35mm theater reproducers, the 16mm field has until quite recently been content to use lightweight, portable, flimsily built 16mm reproducers to meet a highly competitive market condition. Recently, due to the wide use of 16mm film in television, there have appeared several professional 16mm reproducers which tend to overcome this difficulty.

At the standard speed of 18 in./sec for 35mm, the practical upper limit to frequency response is around 8–10 kc. This limit is the result of recording and printing high-frequency losses as well as the losses introduced by the use of a finite scanning slit in reproduction. This has been recognized by the motion picture industry in limiting frequency response of theater systems to approximately 8 kc. In the 16mm field where the film speed is only 40% that of 35mm, it is much more difficult to secure a wide frequency response. It is only by resort to considerable equalization in recording and reproducing that satisfactory response to 6 kc may be made. This inevitable shortcoming of 16mm recording results in the well-recognized "chesty" nature of the sound.

The limiting factor in the signal-to-noise ratio in film recording is the background noise produced by the graininess of the photographic image and also by the accumulated dirt and scratches on the film. This usually limits photographic tracks to a usable signal-to-noise ratio of around 40 db, although new tracks employing fine-grain films and noise-reduction techniques may give a value of at least 50 db.

Even though an excellent photographic track may be obtained from the film processing laboratory, the final result may be considerably affected by the reproducing mechanism. Flutter in the reproducer will produce results equally as disastrous as those from poorly made film recorders. Considerable distortion, especially in the variable-area system, may be encountered by non-uniformity of the scanning beam in the reproducer and even more seriously by failure to have the reproducing scanning beam in the correct azimuth. Other limitations in reproducing, especially in 16mm, are low-cost amplifier systems which do not have sufficient output capacity for the higher-level passages on the film and insufficient hum filtering which in many cases permits an audible 60-cycle reproduction from the loudspeaker. In the matter of loudspeakers, the photographic system probably fares better than either of the other two methods. There has been a vast improvement in loudspeakers in professional 35mm theaters. This cannot be said, however, for the speakers used in the lower-cost portable 16mm reproducing systems.

Magnetic Recording

In common with the other recording techniques discussed above, magnetic recording is also affected by uneven motion of the magnetic tape or film in the recorder and reproducer. The extreme flexibility of the standard $\frac{1}{4}$-in. tape aids considerably in simplifying the tape-pulling mechanism and it is possible to obtain considerable freedom from very low flutter rates with a relatively inexpensive drive. The common capstan-type drive usually introduces low-frequency flutter rates which, however, are considerably higher than those encountered in disk recording and are, therefore, not so objectionable to the ear. Magnetic recording, however, does

introduce a considerable amount of high-frequency flutter of a somewhat random nature which may be traced to the irregular motion of the tape or film over the magnetic head. Fortunately, these rates are sufficiently high so that their effect on the ear is negligible except at the higher audiofrequencies such as some of the higher overtones from string instruments. This irregular motion of the tape over the magnetic head also introduces considerable amplitude distortion which produces an effect almost indistinguishable from that of the high-frequency flutter. Thus, at the commonly accepted speed of 15 in./sec, both of the effects produce a very harsh quality if the sound spectrum is pushed up to the 15-kc limit.

Magnetic tape recording utilizing the high-frequency bias may be reproduced with a minimum of distortion which is generally lower than that in either disk or photographic recording. At the same time, a signal-to-noise ratio of 50 to 60 db may be obtained. This, however, calls in recording for a very high-quality, high-frequency bias oscillator with a second harmonic content about 60 db lower than the fundamental. The ratio of the high-frequency current to the maximum audio current must be of the order of 10 to 20. To achieve the low noise level and relative freedom from distortion, extreme care must be taken to insure that the magnetic head and associated shield do not acquire any permanent magnetism, as the d-c magnetic field thus produced acts in a manner directly analogous to the presence of second-order harmonic components in the high-frequency bias oscillator. One common result of these d-c fields is a pronounced rumble in reproduction. This same effect may also be traced to improperly erased tape. With the proper value of high-frequency bias for any given magnetic head and tape, the distortion above the so-called overload of the medium is mostly third-order harmonic components, the second-order being almost entirely absent. Experience has shown that considerable overload may be tolerated and this is generally attributed to the absence of the more unpleasant even-order harmonic components. A disturbing factor in $\frac{1}{4}$-in. tape is the presence of so-called "print-through" from layer to layer, resulting in what appears to the listener as an echo. This can be prevented by reducing peak amplitudes in the recording and may be prevented from becoming too serious by avoiding storage of recorded tape in excessive high-temperature locations or in the proximity of high magnetic or electrostatic fields.

The frequency response from magnetic film recorded at constant current input to the recording head increases at a 6 db per octave rate over a considerable portion of the audio spectrum. It then flattens off and begins a fairly sharp decline. This dropping off at the upper frequencies results from two causes — one, demagnetization in recording at the shorter wavelengths; and two, the scanning losses which are directly analogous to those found in film reproduction. For a 0.5-mil reproducing gap and speed of 15 in./sec, this fall-off in high-frequency response begins in the neighborhood of 2000 to 3000 cycles. It is customary to correct for the 6 db per octave slope by inserting a simple *RC* correcting network in the reproducing circuit, and a fairly flat response may be obtained down to approximately 100 cycles by this simple expedient. Below this point, irregularities in low-frequency response are frequently encountered, and more complicated means of equalization must be employed if these are to be smoothed out. To insure a wider, higher frequency response, equalization must be used and it is customary to do this partly in recording and partly in reproducing. As pointed out above, a tape speed of 15 in./sec in response may

be made flat out to approximately 15 kc without resort to excessive equalization.

One of the problems peculiar to magnetic recording is the care that must be taken to avoid excessive 60-cycle hum pickup in the reproducer. Since the common power-line frequency of 60 cycles may have a gain 20 to 30 db higher than say 1000 cycles in order to correct for the nonlinear frequency response referred to above, the pickup head and the input circuit, especially the input transformer of the preamplifier, must be well shielded to avoid pickup from ambient 60-cycle fields. Fortunately, the well-known ear characteristic for medium sound reproducing levels aids in reducing the effect of such a disturbing frequency. The ear's being at least 20 db less sensitive at this frequency than at a 1000-cycle tone means that an effective signal-to-noise ratio of 40 db at 60 cycles will be equivalent to a 60-db signal-to-noise ratio at the higher frequency.

In conclusion, we may note that all three media have their own particular factors that limit their fidelity. When all factors including economic are taken into consideration, the magnetic medium appears to offer the greatest possibility of high-quality sound reproduction with a minimum investment in recording and reproducing equipment. The re-use ot the tape and the general simplicity of operation are other factors which seem to be responsible for the remarkably wide use of the magnetic medium in the very short period since its general introduction in this country.

A Building-Block Approach to Magnetic Recording Equipment Design

By KURT SINGER and J. L. PETTUS

The requirements of magnetic recording equipment for sound motion pictures have been found to vary greatly with different customers. In order to provide the necessary flexibility to meet these different requirements and to include various custom features, the functional units of a magnetic recording channel have been designed on separate rack-mounted panels which can be installed in varying arrangements in a standard amplifier rack. These include items for both single-track and three-track equipments, and film widths of 16mm, 17½mm and 35mm.

THE EQUIPMENT required for a sound recording plant varies widely depending on the type of recording, the size of the associated studio, and the magnitude of the plant operation. In this respect magnetic recording or reproducing equipment differs in considerable detail over its predecessor, photographic recording and reproducing equipment. In the latter case, certain facilities were necessarily reserved for photographic film handling. These included dark rooms, film magazines and lighttight enclosures in the recording facilities. In contrast, magnetic equipment offers some consolidation in plant layout as well as certain conveniences in operation.

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by Kurt Singer and J. L. Pettus, Radio Corporation of America, RCA Victor Div., Engineering Products Dept., 1560 N. Vine St., Hollywood 28, Calif.

The requirements of magnetic recording/reproducing equipment for sound motion pictures have been found to vary greatly with different installations. These requirements plus the fact that many studios will wish to install minimum equipment at the beginning and "grow" with the development of magnetic recording, led the authors to the conclusion that studio equipment should be made of carefully planned units so coordinated that they could be easily fitted together to provide almost any desired combination of equipment layout. This is essentially the "building block" idea which is today employed in many types of industrial apparatus. Thus, when expanding a system such as from a few magnetic recording channels to a more comprehensive system or from a single-track to a triple-track recorder/-reproducer, it is not necessary to add entirely new recorder mechanisms but rather to increase the number of compo-

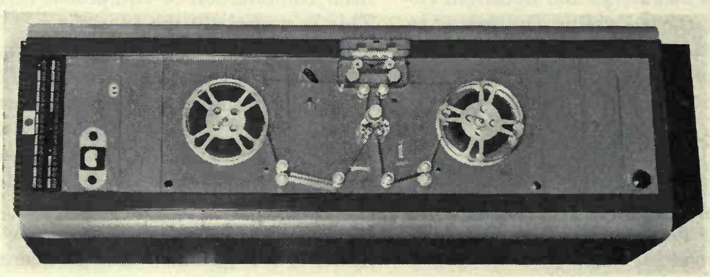

Fig. 1. Single-rack assembly, Type A equipment.

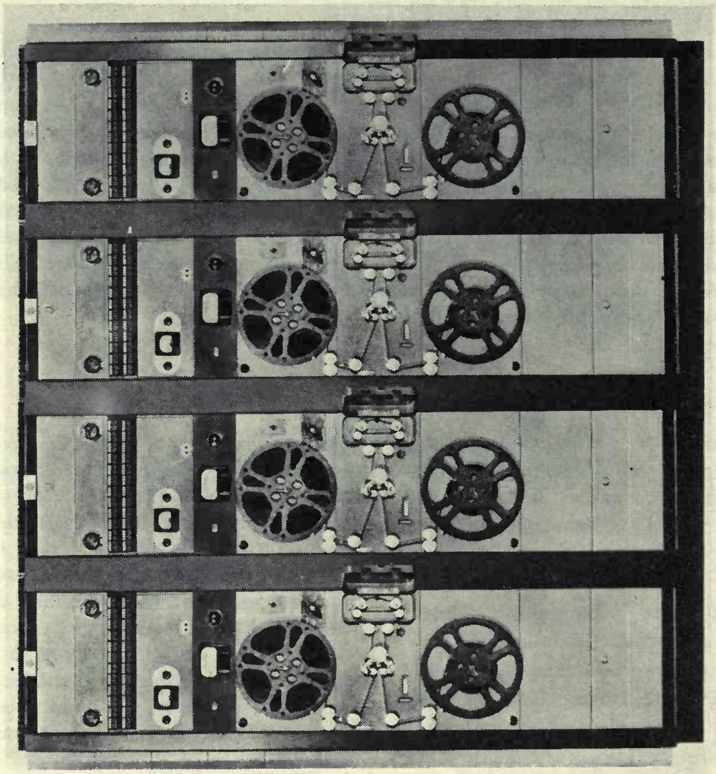

Fig. 2. Multiple-rack assembly, type A equipment.

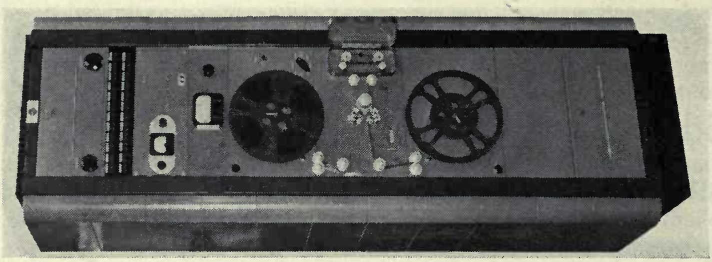

Fig. 3. Single-rack assembly, Type B equipment.

nents as desired. Moreover, this is readily possible if all of the component assemblies have been designed to mount on a standard relay cabinet rack or equivalent having the industry standard multiple dimensioning. The three system layouts described in the following text have been chosen to illustrate the wide range of equipment combinations which are practical. For the most part, these are actually in use or are now being installed in several large motion picture studios.

Of the different equipment combinations to be described, types A and B utilize a single magnetic track while type C provides three sound tracks having all tracks recorded and/or reproduced simultaneously and positioned in accordance with Motion Picture Research Council proposed standards.[1]

Basic Mechanical Arrangement

There are several ways of arranging components in the vertical plane but these generally follow the rules of hand and eye levels for those items requiring the greatest amount of operation attention. An example of a single-track magnetic recorder/reproducer channel is shown in Fig. 1 and identified as RCA type PM-66 equipment. Here the extreme upper portion of the rack supports the bias oscillator/preamplifier followed by a film-feed assembly, a control panel, a film-drive mechanism, a film take-up assembly after which are located power supplies and other miscellaneous audio components. Figure 2 shows a number of these units assembled in line for a multiple-channel installation, yet with each unit being capable of independent operation.

Figure 3 shows a type B arrangement for application where it is desirable to reduce the vertical height of the mechanical components to a minimum. Here the controls have been relocated on the film-feed assembly to conserve space. As in the type A equipment, the audio components are located above and below the mechanical units and positioned as to their operating convenience.

Type C equipment is shown in Fig. 4 as an arrangement which provides a three-track magnetic recorder/reproducer channel and is identified as RCA type PM-63 equipment. Here it was necessary to assemble all audio components in two racks and all mechanical components in a third rack. All racks are tied together to form a single and complete unit assembly. Such an arrangement provides for maximum serviceability to all elements but occupies only minimum plant space. Here again many components as shown in Fig. 1 are used with only minor alteration to the film-drive mechanism for the number of magnetic-head assemblies employed.

Selection of component assemblies in practice follows the requirements and specifications for a given installation. To begin with, the width of the recording medium, the number of magnetic tracks per channel and the required film capacity determine the basic elements. In general, the width of the film does not alter the basic design except for the physical size of certain parts and the speed of the film-driving mechanism. This latter difference has been chiefly limited to the use of 16mm film operating at 36 fpm and 17½ or 35mm film operating at 90 fpm. However, in view of further economy in magnetic recording, the use of 17½mm film operating at 45 fpm for all original or production recording, is gaining favor in the industry. Magnetic recording equipment for 45 fpm operation was presented before this Society in a paper entitled "A Technical Solution to Magnetic Recording Cost Reduction."[2]

The number of magnetic tracks regardless of the width of the film has been primarily limited to the use of a single track on all widths for production recording and triple tracks on 35mm film in dub-

Fig. 4. Triple-track rack assembly, Type C equipment.

bing or re-recording operations. Of course, there are many possibilities of using a plurality of tracks on either of the other two film widths.

Description of Mechanical Components

A. Film Feed and Take-up Assemblies. A panel of approximately 15$\frac{3}{4}$ in. high will accommodate a film capacity of 2000 ft. This size was chosen as being most satisfactory in the majority of installations. In the past, many recorder/reproducer designs have used a rather simple friction-type clutch as an integral part of the feed and take-up assemblies to tension or wind the film on the respective film reels. The applied tension between start and finish pay-out or take-up of a 2000-ft-roll of 35mm film wound on a 2-in. diameter core, was found to vary by a ratio of 1:8 under average operating conditions. Such a variation reflects an undesirable condition to the film-drive mechanism. Furthermore, the desire to incorporate rewinding from reel to reel as a feature on new equipment is well founded.

These two factors guided the design to make use of a torque-type motor to serve as a tensioning device having a nearly linear characteristic for both holdback and take-up as well as being suitable for a high-speed rewind. The first function was obtained by applying varying potential to the motor in proportion to the amount of film on the reel and phased for rotation opposite that of the film pay-out. This provided an ideal holdback system. Similarly, it also provides an ideal take-up system except that rotation of the torque motor must agree with the direction of film winding and have somewhat greater torque. The third function

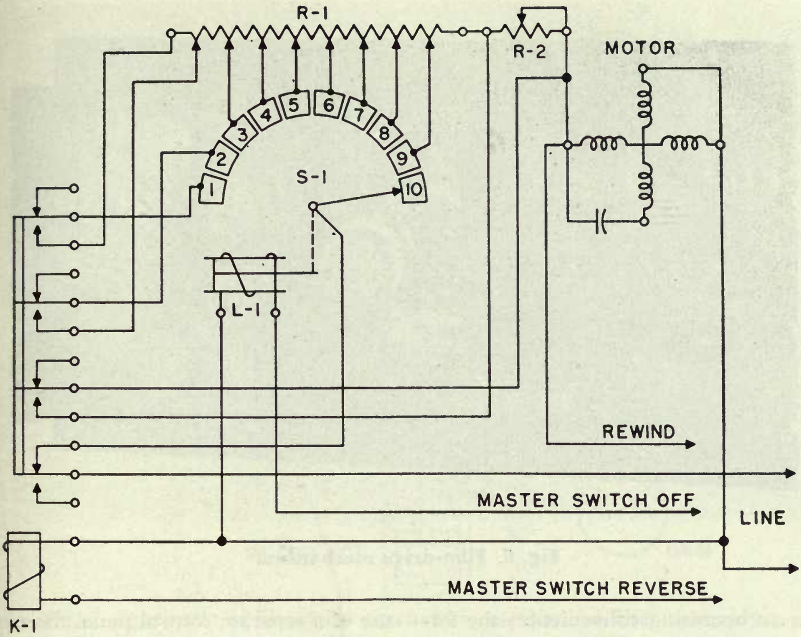

Fig. 5. Schematic of torque motor voltage controller.

as a rewind was obtained by using the motor at its rated output as a propulsion device. The electrical elements of this assembly are shown schematically in Fig. 5. From this, it will be noted that the use of a variable series resistance (R-1) in one leg of a single-phase motor, serves to vary the motor torque for either holdback tension or forward torque for take-up. The resistor (R-1) is varied by a commutator (S-1) by means of a follower arm in contact with the periphery of the film roll. Additionally, a relay (K-1) is used to vary the overall torque curve when the motor is functioning for a take-up instead of a holdback as in the case of reverse operation. This relay is normal in the holdback function and energized by the master control switch for the reverse or take-up function. As shown in Fig. 5, the commutator switch (S-1) is in its initial position at the maximum film roll diameter thus placing the least amount of R-1 in series with a second resistor (R-2) and this combination being seen by one leg of the torque motor. As the commutator switch progresses with a decrease in film roll diameter, sections of R-1 are automatically added, proportionally reducing the motor torque. As the last two steps are reached, R-1 is opened allowing only the inherent load of the motor-drive assembly to serve as friction in the holdback function, these two steps being at diameters less than 5 in. When functioning as a take-up device, relay K-1 becomes energized and shorts out R-2 to increase the overall torque range. Additionally, steps 1 and 2 of S-1 are seen by R-1, thus giving a potential to the motor at the minimum or starting diameter of the take-up roll. Controlling the torque of each motor by the described method produced a film tension characteristic constant within 2 oz throughout the length of a 2000-ft reel using a 2-in. OD core.

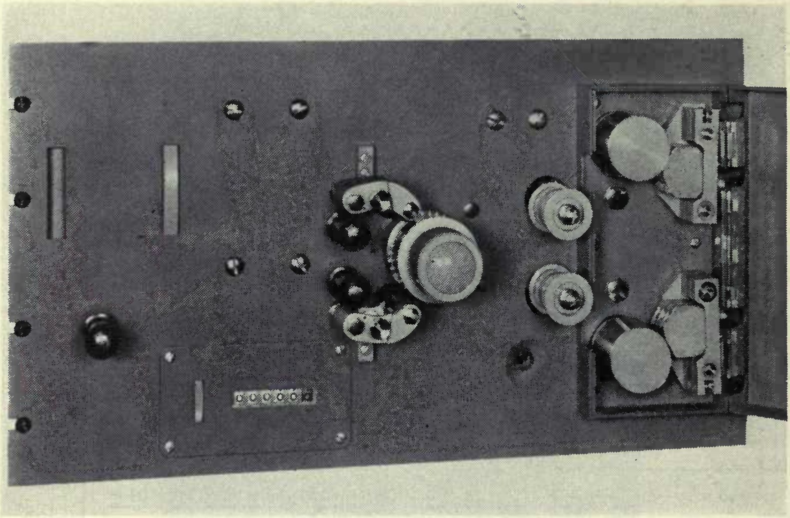

Fig. 6. Film-drive mechanism.

As an operating convenience, the follower arm is automatically retracted from the film reel by means of a solenoid energized through the master control switch when positioned at OFF. Upon setting the master switch for the desired operation of the film drive, the follower arm is released and allowed to seek the periphery of the film roll. Thus, a predetermined potential to the torque motor is automatically established.

B. Control Panel Assembly. As shown in Fig. 1, controls for the film-drive mechanism, as well as for rewinding, are mounted on a separate panel. An exception to this arrangement was shown in Fig. 3 where these controls were placed on the film-feed assembly in order to conserve rack space for a particular installation. In general, the separate panel allows the use of larger film reels and gives several operating as well as manufacturing conveniences. In the latter respect, the associated film-drive mechanism may use any of the industry standard motors including the combination synchronous/interlock type. The use of a separate control panel therefore permits a variety of electrical combinations to suit the associated motor systems without alteration of the other electrical circuits. Figure 1 shows the master switch designated for operation of a combination synchronous/interlock film-drive mechanism motor. This switch is divided into eight positions in order to give independent switching for the respective sections of the motor. It is also seen that on either side of the OFF position for synchronous motor control, there appears a READY position which permits energizing the feed and take-up motors before completing the circuit to the film-drive mechanism motor. Thus, the torque motors, being pre-energized ahead of the actual rolling of the overall mechanism, remove all slack in the film path and permit the feed and take-up reels to follow the acceleration or deceleration of the film-drive mechanism motor. READY positions for interlock operation are not required since the torque motors are energized on the LOCKING cycle of the interlock motor system.

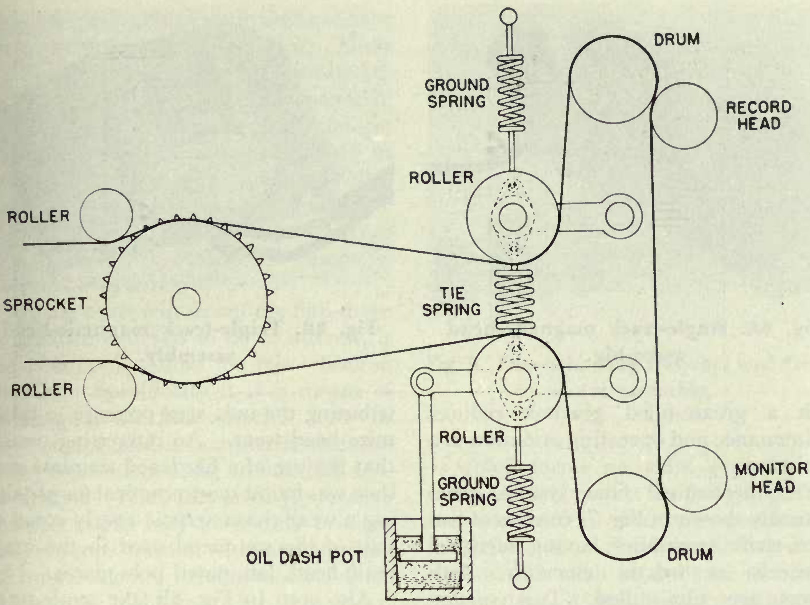

Fig. 7. Schematic of film-drive mechanism mechanical filter assembly.

A key switch, which controls the respective torque motors through relays, allows film to be rewound from reel to reel with the direction established by the position of the key. For instance, if rewinding is to be from the lower to the upper reel, positioning the rewind key switch in the UP position connects the upper motor for maximum torque and likewise connects the lower motor for reduced and reversed torque in order to establish tension in the film. Rewinding in the reverse position follows a similar procedure.

C. Film-Drive Mechanism. This assembly might well be considered a basic item in the building-block plan for a magnetic recorder and/or reproducer unit. The foregoing discussion is therefore primarily concerned with the accessory items required by the film-drive mechanism but varied to suit a particular installation. Figure 6 shows the components of the drive unit. The base of this assembly consists of a cast aluminum alloy plate occupying $10\frac{1}{2}$ in. of vertical rack space. Attached to this plate are a drive motor, a mechanical filter system, magnetic heads — either single- or triple-type — a footage counter and several film-guide rollers, etc. The drive motor is worthy of mention to the extent that an integral part of it is a reduction-gear unit whose output shaft is suitable for direct coupling to the film-drive sprocket. The speed reduction from motor to sprocket is obtained by single-series helical gearing. Ratios varying between 10:1 and 125:9 to suit the many permissible different types of motors and film speeds are used. Since the drive motor does not power the take-up system, its frame size has been reduced to a minimum while maintaining a power output in the order of 3:1 over that of the actual torque requirement. This motor unit develops approximately 20 mechanical watts when designed as a three-phase motor and somewhat more when designed as an interlock-type motor. The use of permanently lubricated bearings together

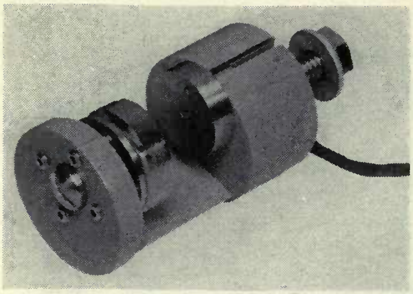

Fig. 8A. Single-track magnetic-head assembly.

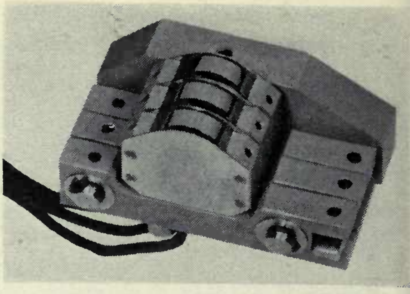

Fig. 8B. Triple-track magnetic-head assembly.

with a grease-filled gearbox reduces maintenance and operating attention to a minimum.

The mechanical filter system, schematically shown in Fig. 7, consists of two drum-shaft assemblies having identical flywheels as inertia elements. Both drums are film-pulled. Two sprung tensioning rollers with damping applied to one tension roller comprise the other elements of the filter system, the damping being obtained by means of a fluid silicone oil type dashpot connected to one roller arm by a mechanical linkage. The entire system is near critically damped with a resonant frequency of approximately $1\frac{1}{2}$ cycles/sec.

Magnetic head assemblies may be, as previously mentioned, selected to suit the particular requirements of the installation, i.e., single- or triple-type tracks. Either assembly is interchangeable with respect to the film-drive unit. The single-track type is shown in Fig. 8A. Here it is seen that the head is mounted by means of a one-piece holder having a ball-and-socket type of anchorage which allows longitudinal, lateral and transverse adjustments of the head with respect to the recording medium.[3] The use of a shoe which contacts the film on the edge opposite the sound track, and which is of a width equal to the magnetic track, has been found advantageous. This shoe maintains the plane of the film across the magnetic head as well as distributing the unit area pressure to minimize head wear. An interesting note is that the use of a hardened stainless steel shoe was found most practical for obtaining a wear characteristic nearly equal to that of the mu-metal used in the magnetic-head, laminated pole pieces.

Also seen in Fig. 8B, the triple-track assembly employs three heads arranged in line and positioned in accordance with the Motion Picture Research Council's proposed standards for sound-track positions.[1] This assembly, while obviously more complex than that of the single-track magnetic-head unit, provides the same individual head adjustments although accomplished in a somewhat different manner. The lateral or azimuth adjustment of each head is obtained by pivoting the head-mounting yoke on a supporting arm. The transverse adjustment is obtained by pivoting the individual arms on a lateral supporting shaft, and the longitudinal adjustment is obtained by moving the entire head assembly with respect to the mounting base.[3] No supporting shoe is required by the triple-track assembly since the heads themselves contact the film uniformly across its width. The construction of the magnetic head proper, used in both single- and triple-track units, follows that described by Rettinger.[4]

When the film-drive mechanism is to serve as a recorder with monitoring, two identical head assemblies are employed,

each assembly being positioned near the respective drum-shaft assemblies. These positions were chosen after extensive investigation for optimum performance in both constancy of motion and uniform output from the recording medium. A more comprehensive discussion of this investigation was presented before the Society in a paper entitled "Twin-Drum Film-Drive Filter System for Magnetic Recorder-Reproducer."[5]

Among other features of the film-drive mechanism believed to be of interest, is one commonly called the free-wheeling sprocket. Specifically it is a means of disengaging the film sprocket from its drive source and is considered essential to any reproducer using an interlock motor system. With this facility, synchronization marks may be readily brought to a reference position without disturbing the interlock of the driving motor. Such an assembly is shown in Fig. 9 in an expanded view. Essentially, this consists of a multi-jaw coupling which may be manually disengaged to free the film sprocket. It will be seen that one-half of the multi-jaw coupling is fixed to the sprocket drive shaft and following this is a spinner knob which contains the mating half of the multi-jaw coupling, free to rotate on the shaft. On the rear side of the spinner knob is a driving pin which accurately engages at all times with a hole in the film sprocket proper and therefore serves to drive the latter. Between the spinner knob and the sprocket lies a compression spring which normally forces the spinner knob toward the fixed half of the multi-jaw coupling. By exerting an inward force on the spinner knob, the coupling becomes disengaged and the film sprocket is then "free-wheeled." Following the sprocket is a collar which is likewise driven by a pin engaging the film sprocket and rotates at all times with the sprocket. On the rear face of this collar is a ladder-chain sprocket which drives the footage counter in synchronism. Behind this is a smaller collar — fixed to the drive shaft

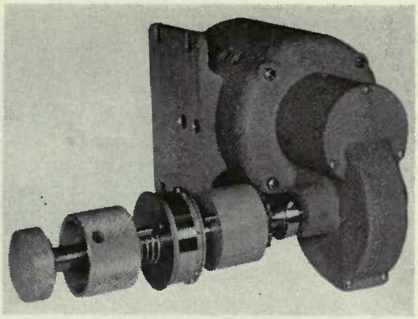

Fig. 9. Free-wheeling sprocket and drive-motor assembly.

— which forms an axial stop for the entire assembly when the foregoing items are assembled in their true position on the drive shaft. Since the film sprocket contains 32 teeth in the case of 35mm applications, a multi-jaw coupling also having 32 teeth was chosen. It follows therefore that synchronism is maintained within one sprocket pitch for 35mm film and to an even closer degree for 16mm film where the sprocket contains 20 teeth. This arrangement will advance or retract film through the driving mechanism at the rate of approximately 6 in. per revolution of the spinner knob.

D. Accessory Equipment. In the building-block plan, a number of accessories have been developed to provide additional conveniences in operation as well as a means of reducing production costs. These include: (a) magnetic erasing facilities while recording either single or triple tracks; (b) a predetermining rewind footage counter; and (c) photographic-type sound reproducers for both 16mm and 35mm films. The erasing unit employs two erase heads in cascade for each sound track, making a total of six heads in the unit. The geometry of the film path between feed reel and film-drive mechanism is slightly modified to bring the erase unit into use. This consists of threading the film about a series of

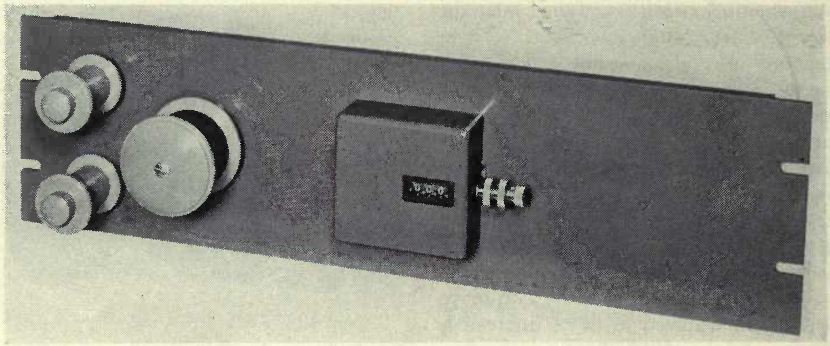

Fig. 10. Predetermining counter assembly.

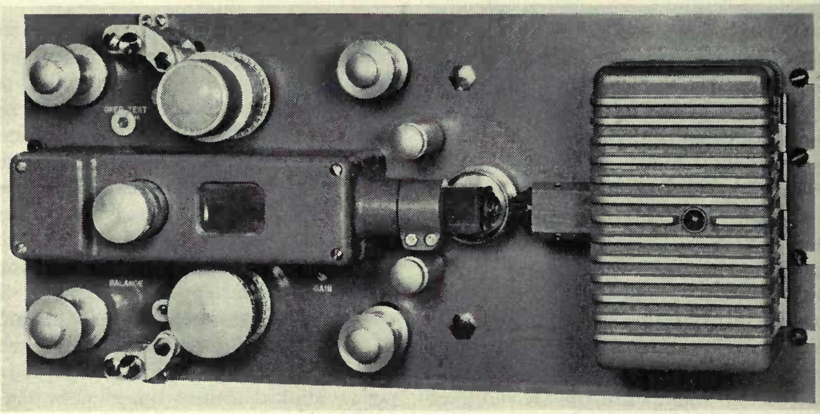

Fig. 11. 35mm photographic reproducer assembly.

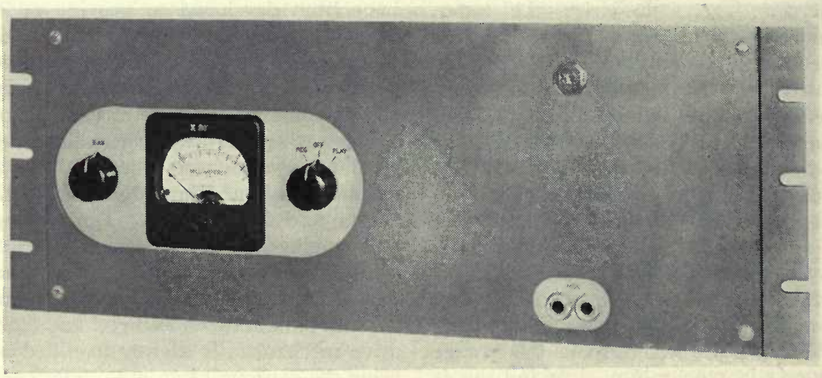

Fig. 12. Oscillator–preamplifier.

fixed rollers which allow the film to contact the erase heads. When erasing is not wanted, the film is threaded directly past the erasing unit. Thus, the difference in film threading, plus an enclosure around the erasing heads, reduces the accidental use of the erasing facilities to a minimum. Each erase head dissipates 1.6 w, making a total of 3.2 w per track of erase current power. The frequency is nominally 68 kc and derived from the recording bias oscillator. This amount of erase power provides a 70-db erasure below 100% modulation or results equivalent to that obtained by the conventional 60-cycle bulk eraser.

The predetermining footage counter accessory is shown in Fig. 10. It is used in rewinding to a given point without operator attention. A specific use for this convenience is, for example, in scoring music, where playbacks and transfers are involved. This assembly consists of a special counter which is film-driven and several additional relays in the electrical circuit for controlling the film feed and take-up torque motors. In operation, the counter is set to a given number of feet to be rewound and the rewind control switch positioned in the desired direction of rewinding. As the film travels from reel to reel, the counter subtracts toward zero. At 10 ft from zero the counter anticipates and trips an electrical control which applies a braking voltage to the respective torque motors. This braking action is maintained by a time-delay relay circuit during the deceleration period, and when the counter reaches zero both the braking action as well as the power are released. At this point, the torque motors are automatically restored to their normal functions of feed and take-up. The footage counter is driven by wrapping the film about a large rubber-tired roller, with the degree of wrap being maintained by two smaller rollers of the conventional type. When the predetermining counter operation is not wanted, the film path for rewinding is threaded to by-pass the counter drive. The electrical control elements have been designed to stop film travel within two to three feet of a given point, this point being in the direction of over-travel. The starting point is then brought into view during rethreading of the film-drive mechanism, since the operator's natural tendency is to pull this amount of slack film from the feed reel for the threading operation. Exact synchronism is then obtained by turning the free-wheeling sprocket.

The third accessory item is a photographic sound reproducer unit for both 16mm and 35mm applications. The latter, shown in Fig. 11, is suitable for 100-mil standard, 100-mil push-pull and 200-mil push-pull sound tracks. It is believed that most sound-recording plants find it necessary to handle photographic records at different times regardless of the extent of their magnetic plant facilities. Since many of the components of a magnetic reproducing channel might well be common to a photographic reproducing channel, it is logical that a dual-purpose reproducer will reduce the over-all plant investment. Again the building-block plan permits the use of another unit in conjunction with those items considered common to either type of reproducer. The photographic sound reproducer need have only the necessary optical-scanning facilities and a means of directing the film for scanning. This has been accomplished by mounting the necessary optical elements on a panel $8\frac{3}{4}$ in. high and assembling in the standard relay rack directly below the magnetic film-drive mechanism. The photographic reproducer contains its own mechanical filter system but its driving power is derived from a synchronous rubber-belt drive from the magnetic film-drive unit. In operation, the film is threaded to by-pass the magnetic unit. Likewise, the photographic unit is by-passed when using the magnetic unit. Preamplifiers for both the 16mm and 35mm reproducers are mounted directly behind the respective mechanisms and

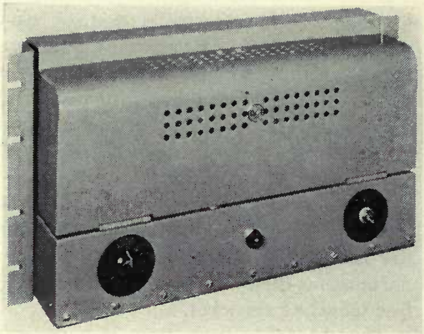

Fig. 13. Erase amplifier (front view).

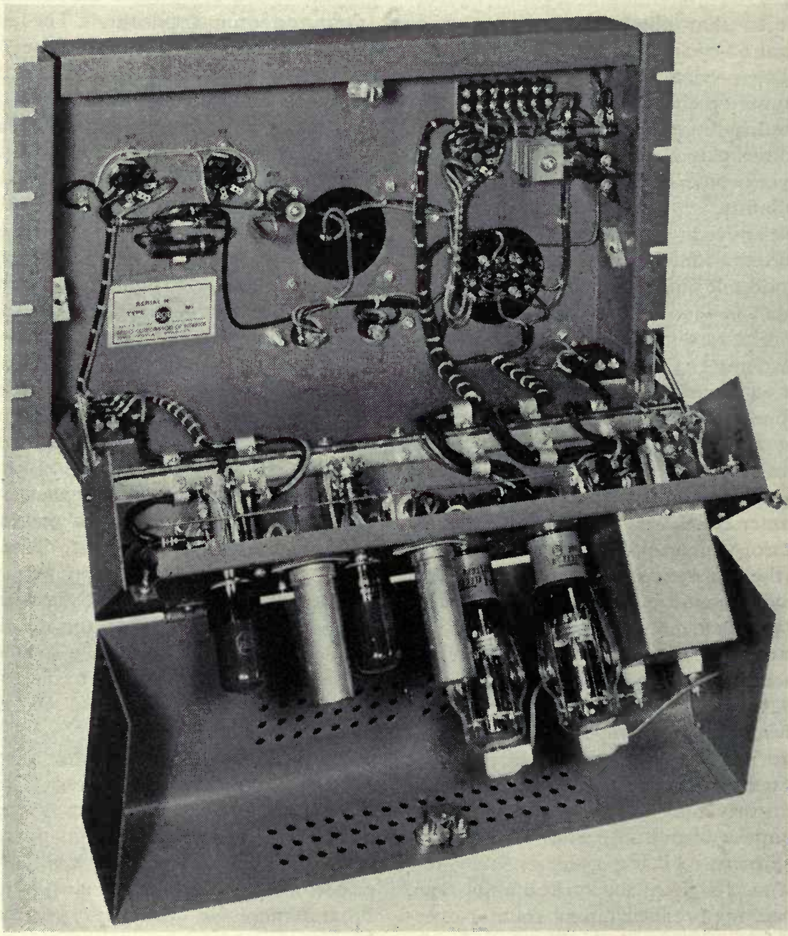

Fig. 14. Erase amplifier (service position).

provide an output level of approximately -2 dbm and -12 dbm, respectively.

A variety of amplifiers and bias oscillators are available to complement the above-mentioned alternative equipment arrangements. For single-track recording and reproducing, the amplifier-oscillator known as MI-10248 or MI-10248-A, shown in Fig. 12, is provided. This unit contains a combining network, bias oscillator and bias meter. In addition, it also provides for a separate self-contained playback amplifier capable of amplifying the signal from the monitor head to a level of $+4$ dbm. Output impedances of 10, 250 and 600 ohms are available so as to provide for headset monitor or for transmission to the re-recording channel. Suitable switching facilities deactivate the oscillator during playback or in the OFF position. The oscillator also contains a high-frequency boost equalizer which is used to shape the recording characteristic to obtain flat output to 8000 cycles. A separate winding on the oscillator coil permits connection to an MI-10263 Erase Amplifier as shown in Figs. 13 and 14. By means of this amplifier, it is possible to raise the output voltage from the oscillator to a level sufficient for erasing. This erase amplifier contains its own a-c power supply and is capable of delivering 50 w at 68 kc at a distortion of less than 0.5%. At normal erase power requirements, the wave-form distortion from this amplifier is on the order of 0.1% or less.

For triple-track recording or reproducing, a three-channel bias oscillator is provided. This oscillator, known as the MI-10228-A, is usually mounted together with the MI-10262-A Switching Panel on a common frame and is shown in Figs. 15 and 16. A master oscillator operating at a nominal frequency of 68 kc supplies three independent push-pull amplifiers which in turn furnish bias current to the three recording heads. The switching panel permits the combining of the bias currents with the signal before it reaches the heads and also provides switching means for turning the MI-10228-A oscillator on and off. Three separate bias meters are contained on the switching panel to permit independent metering of the three recording heads. For playback, there are available plug-in amplifiers (Fig. 17) which may be connected singly or in cascade so as to obtain almost any desired output level from the reproducing heads with frequency characteristics flat up to 8000 cycles. Six such playback amplifiers are housed on a common shelf. These six amplifiers furnish the playback amplification for a triple-track reproducing setup. For recording amplifiers, plug-in amplifiers, in external appearance very similar to the playback amplifiers, are available. However, any power amplifier capable of providing a level of $+22$ dbm at an output impedance of 600 ohms, may be used. In order to obtain the optimum signal-to-noise ratio, we have standardized on the use of a low-frequency pre-equalizer during recording. This unit, shown in Fig. 18, raises the 60-cycle region of the recording characteristic by 6 db and consequently permits the use of 6 db less post-equalization during reproducing. This expedient reflects in a gain in signal-to-noise ratio, since hum frequencies, such as 60 cycles, now require 6 db less playback amplification. The insertion loss of this constant resistance equalizer is 10 db. It may be connected before or after the power amplifier dependent on the power-handling capacity of this amplifier. The performance of these magnetic channels is best expressed by stating that the overall frequency response is flat within 1 db from 40 to 8000 cycles at film speeds of 90 or 45 fpm, and flat within 1 db from 50 to 7000 cycles at film speed of 36 fpm. The signal-to-noise ratio is consistently 60 db or better, referred to 100% modulated track. In order to obtain this performance, all heaters are operated from d-c supplies which have a ripple content of 6 mv or less. The ripple content of the B supplies is 1 mv or less. The flutter

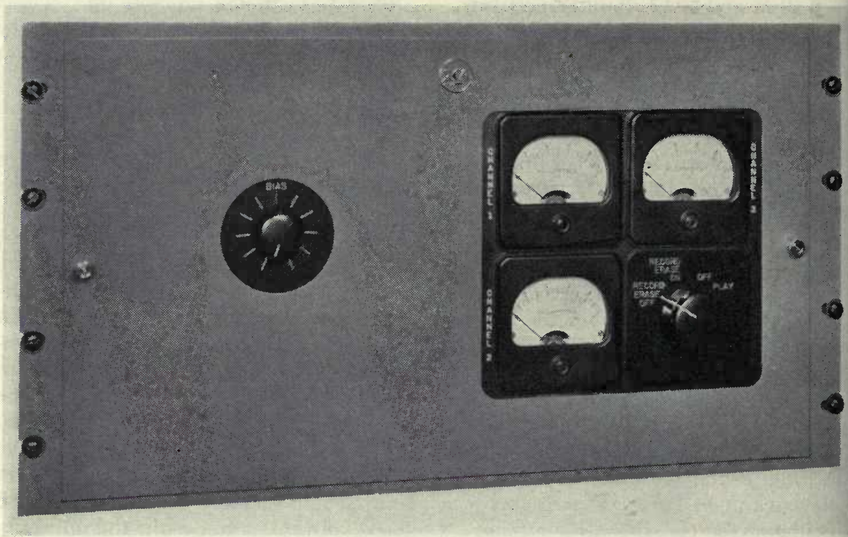

Fig. 15. Triple-track oscillator and switching panel.

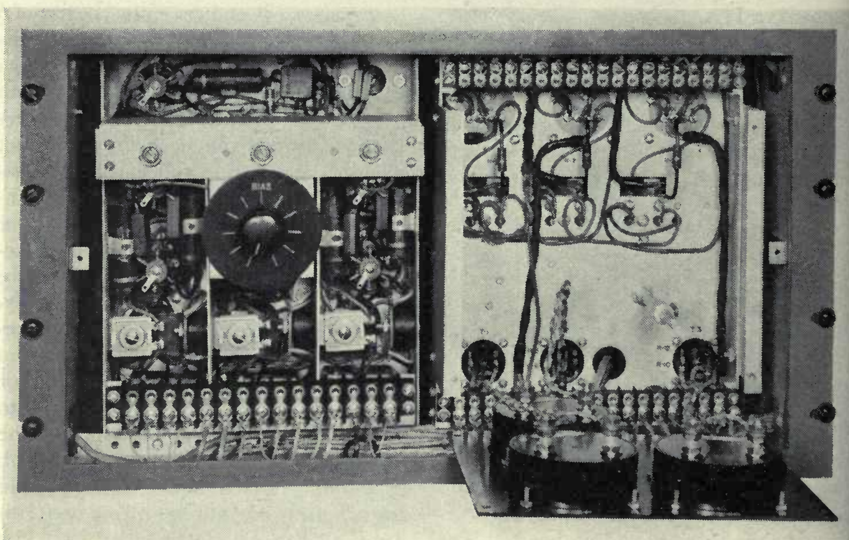

Fig. 16. Triple-track oscillator and switching panel (cover removed).

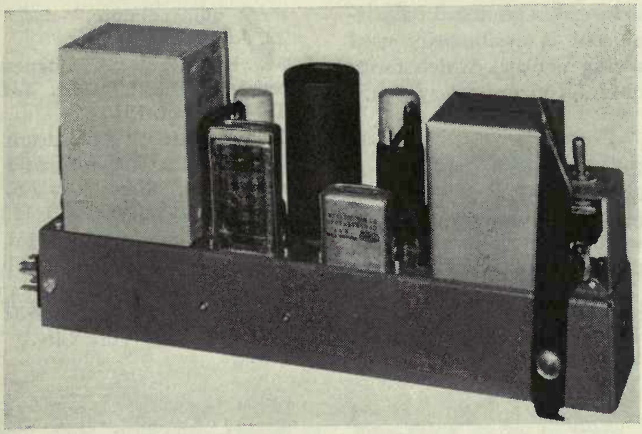

Fig. 17. Magnetic playback amplifier.

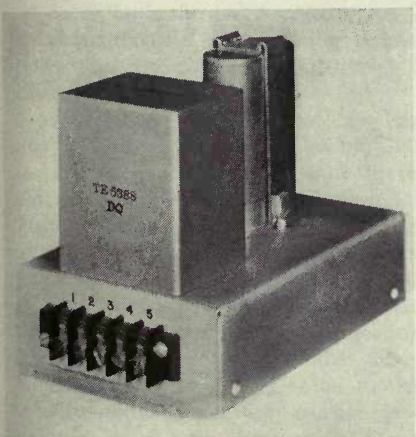

Fig. 18. Recording equalizer.

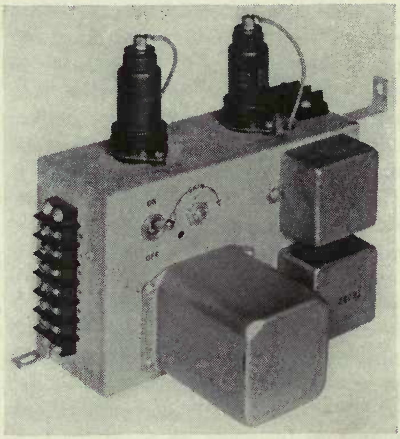

Fig. 19. 16mm photocell amplifier.

content of a recording reproduced on either single- or triple-track equipments is less than 0.1% rms total with less than 0.05% rms being 96 cycles flutter.[5] Rewinding speed is approximately 900 fpm. Starting time is in the order of 4 sec for 35mm or 17½mm equipment at 90 fpm, and approximately 5 sec for 16mm equipment at 36 fpm.

In order to complement the photographic-film reproducing facilities the following amplifiers are available:

1. For 16mm reproducing, the MI-10239-A, shown in Fig. 19, can be supplied. This is a two-stage negative feedback amplifier capable of furnishing photocell polarizing potential and of amplifying the output from a photocell to a level of −10 dbm.

2. For the reproducing of 35mm optical track there is available an amplifier of the plug-in broadcast type known as MI-10271 which in appearance is similar to magnetic playback amplifiers. This

amplifier also furnishes photocell polarizing potential and is customarily used with a balancing network which forms part of the MI-29135 optical system.

References

1. Motion Picture Research Council Recommendation 58.301-B.
2. Kurt Singer and H. Connell Ward, "A technical solution of magnetic recording cost reduction," *Jour. SMPTE, 58:* 329–340, Apr. 1952.
3. Terms are those defined by N. M. Haynes, "Magnetic tape and head alignment nomenclature," *Audio Eng., 33:* 22, June 1949.
4. M. Rettinger, "A magnetic record-reproduce head," *Jour. SMPTE, 55:* 377–390, Oct. 1950.
5. Carl E. Hittle, "Twin-drum film-drive filter system for magnetic recorder-reproducer," *Jour. SMPTE, 58:* 323–328, Apr. 1952.
6. Proposed American Standard, Z57.1/68, Method for Determining Flutter Content of Sound Recorders and Reproducers, American Standards Assn., 70 E. 45 St., New York City.

A-C High-Intensity Arc Slide Projector

By ARTHUR J. HATCH

This paper describes a high-intensity arc slide projector which is powered from a 110-v, 60-cycle convenience outlet and requires only 10-amp supply. The resulting intensity of illumination is sufficient for screens of 35 ft in width.

A modern slide projector, shown in Fig. 1, using a high-intensity a-c carbon arc as a light source, has been developed to cover both the large-screen areas of drive-in theaters and smaller screens where an exceptionally high level of illumination is desired.

With this high-intensity a-c arc adapted for $3\frac{1}{4}$ in. by 4 in. slides, 7500 lm are projected, with no slide in the carrier. Expressed a different way, this 7500 lm projected to a 35-ft wide screen will produce a screen brightness of approximately 9 ft-L, which incidentally is the lower limit of the SMPTE screen brightness range for 35mm projection. For a 50-ft wide picture the screen brightness will be nearly equal to that usually obtained on the average 50-ft drive-in screen with 35mm projection.

With small-size screens of 10 to 12 ft in width, the brightness may approximate 70 ft-L, which is sufficient to obtain a reasonably good contrast even with the normal room lighting remaining on.

The complete projector comprises the arc lamphouse, optical system, slide carriers, and fan and transformer, all assembled as a table unit 78 in. long and weighing 175 lb. The table is adjustable in height by means of its four legs, from 36 in. to 56 in., and tiltable from 10° upward to 30° downward.

The reflector-type arc lamphouse and power supply elements are essentially the same units used in the "Trouper" arc spotlight.* The lamphouse is complete with carbon holders, motor-driven carbon feed, reflector tilt adjustments, arc focus knob and arc imager screen.

The trim of 6 mm by 7 in. copper-coated high-intensity a-c carbons is burned in coaxial alignment at 45 amp and 21 v a-c. The burning time for a single trim of carbons is 1 hr 20 min.

Although the first development with this new a-c projector has been for $3\frac{1}{4}$ by 4 in. slides, simple adaptations can be used to project both larger and smaller material. However, in the case of 2 in. by 2 in. material or smaller, heat-removing means in the form of heat filters or heat deflectors will have to be used in the light beam to prevent damage to the slide.

The optical system is arranged so that the light from the arc is gathered by a $10\frac{1}{4}$-in. diameter elliptical reflector which has a focus of $3\frac{1}{4}$ in. and a working distance of 24 in. This reflector converges the beam of light through a plano-convex lens and thence through the slide aperture to the objective lens.

Presented on April 22, 1952, at the Society's Convention at Chicago, Ill., by Arthur J. Hatch, The Strong Electric Corp., 87 City Park Ave., Toledo 2, Ohio.

* R. Ayling "New portable high-intensity arc spotlight," *Jour. SMPE, 53:* 408–416, Oct. 1949.

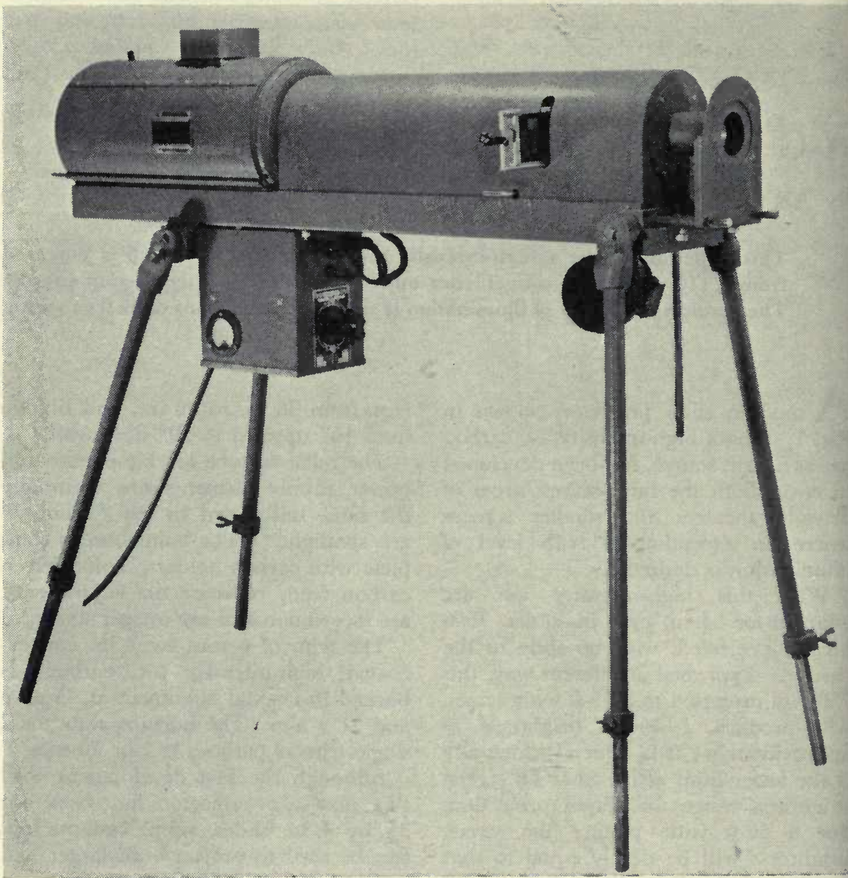

Fig. 1. A-C Arc Slide Projector.

The magnification of the carbon crater on the slide aperture is sufficient to cover a 2 in. by 2 in. slide. When $3\frac{1}{4}$ in. by 4 in. slides are projected, a negative lens is placed in the beam of light between the lamp and plano-convex lens to increase the magnification sufficiently to cover the larger aperture.

The power transformer which isolates the a-c line potential from the lamphouse draws 10 amp from any 115-v convenience outlet and delivers 45 amp at 21 v to the arc. The eight-point rotary tap switch and indicating meter provide a convenient means of compensating for commercial variations in the a-c line voltage.

The indicating meter, in reality a voltmeter with a suppressed zero, is connected across a portion of the transformer primary winding. When the hand of the indicating meter scales in the green zone, the volts per turn of the transformer primary are at the right value to deliver the correct amount of power to the arc. The tap switch is simply turned until the primary volts

per turn are correct as indicated by the meter.

A fan of 50 cu ft/min capacity directs a moving air stream across the slide to prevent damage to the slide. This fan is started when the arc power supply is turned on. With the cooling from this blower, it is possible to project dense $3\frac{1}{4}$ in. by 4 in. slides for periods of an hour or more continuously without visible deterioration to the slide.

The arc "on-off" switch is located at the top rear of the lamphouse. A manually operated dowser interposed just before the slide carrier and lens assembly enables the arc to be burned in a stand-by condition.

Single-element objective lenses have been found suitable for use with $3\frac{1}{4}$ in. by 4 in. slides in the focal length range of 17 in. to 30 in. Corrected objective systems are generally necessary for focal lengths shorter than 17 in.

Discussion

J. A. Tanney (S.O.S. Cinema Supply Corp.): Have you had any experience with wide-angle lenses of comparatively short throw?

Mr. Hatch: I understand that there is a type of lens which has recently appeared which will give a wide-angle picture with a very short throw. It is possible that such an objective system could be coupled with this projector.

Mr. Tanney: What I had in mind was its possible ues in TV studios for backgrounds or in motion picture work for still backgrounds.

Mr. Hatch: We are going to investigate those possibilities in connection with this projector.

Proposed American Standard

PH22.90 Aperture Calibration of Motion Picture Lenses

Starting about 1940, there has been a rapidly growing need in the motion picture industry for a more accurate expression of the photographic speed of a lens than is afforded by the simple *f*-number ratio. The Proposed American Standard appearing on the following pages is the product of many years' industrious and patient effort to achieve agreement on a standard photometric method of aperture calibration. It is published here for 6-month trial and criticism. All comments should be sent to Henry Kogel, SMPTE Staff Engineer, prior to April 15, 1953, along with a carbon for R. Kingslake, Chairman of the Optics Committee.

The problem is essentially this: the density of a photographic image depends on (a) the brightness of the subject, (b) the effective speed of the lens, (c) the speed of the film, (d) the exposure time, and (e) processing of the film. In modern motion picture production all these factors except (b) are controlled or known to within a few per cent, but the supposed speed of the lens may be in error by as much as 60 or 70%. This is caused by loss of light through surface reflections or direct absorption in the lens, and occasionally to incorrect marking of the *f*-number scale.

By August 1947, no less than eight papers on lens calibration had appeared in this Journal.

The Standards Committee, therefore, formed a Subcommittee on Lens Calibration to study the whole subject and to recommend a standard procedure for measuring the effective photographic speed of a lens. In October 1949 the Subcommittee published a report of their investigations and recommendations, which became the basis of the present proposal. The introduction to the report stated in part: "The demand for a photometric type of aperture calibration ("T-stop") is becoming increasingly felt, and it has the advantage that diaphragms of any shape, pentagonal, scalloped or irregular, can be correctly labeled with as much ease as a circular one. The presence or absence of antireflection coatings is automatically accounted for in the calibration, and so also are factory variations in the focal length and in the iris mechanism. Illumination on the film in the center of the field will therefore be the same for all lenses at the same T-stop, assuming that the object is a uniform plane surface perpendicular to the lens axis. It is implicit, also, that each lens shall be individually calibrated if the photometric method is used."

In November 1949 the Subcommittee was given formal status of its own in the creation of the Optics Committee under the chairmanship of Mr. Kingslake. This Committee achieved agreement on the final version of the proposal at its May 3, 1951, meeting and forwarded it to the Standards Committee for processing as an American Standard. The ballot of the Standards Committee on the question of preliminary publication brought forth several negative votes, all of which were based on objections to paragraphs dealing with some of the practical applications of T-stops. These were not fundamental aspects of the proposal and have therefore been eliminated, paving the way for its present publication.

Proposed American Standard

Aperture Calibration of Motion Picture Lenses

PH22.90

1. Scope

1.1 The purpose of this standard is to define the *f* and T numbers used to express the relative aperture of a photographic objective. A second purpose is to establish means for calibrating the diaphragms of objectives in both the *f* and T systems, with suitable tolerance specifications.

1.2 The *f* number of a lens represents a true geometrical measure of the relative aperture.

1.3 The T number is a photometrically determined measure of the relative aperture of a lens adjusted to take proper account of the lens transmittance, so that the illuminance in the center of the lens field will be the same for all lenses at the same T-stop setting. This assumes that the object is a uniform plane diffusing surface perpendicular to the lens axis.

1.4 It should perhaps be mentioned that the photometric calibration of a lens diaphragm as contemplated by the T system of diaphragm marking established by this specification is only one step in extending the control for the purpose of producing negatives of a desired uniform density. The density of a negative is dependent upon the illumination and reflectance of the object photographed, the correctness of the diaphragm marking, the absorption of the lens, the accuracy of timing of the exposure, the uniformity of the emulsion employed, and complete control of the processing. The application of the T-stop system is designed to improve the control as regards correctness of diaphragm marking and absorption of the lens. The importance and need for this particular control increases as the control of the other factors enumerated is improved.

2. Theory

2.1 The illuminance at the center of the image of a uniform plane extended object perpendicular to and centered on the lens axis, when the lens has a circular aperture, is given by

$$E = \pi t B \sin^2\theta \qquad (1)$$

2.2 In this formula: E is the illuminance in lumens per unit of area; t is the lens transmittance, expressed as the ratio of emerging flux to entering flux for a beam sufficiently narrow to pass through the lens without obstruction by the lens mount; B is the object luminance in candles per square unit; and θ is the semiangle of the cone subtended by the circular exit pupil of the lens at the point where the lens axis intersects the image plane.

2.3 If the lens can be assumed to be aplanatic, that is, to be free from spherical aberration and to satisfy the sine condition, and if the object is very distant, then the value of sin θ will be given by

$$\sin\theta = \frac{Y}{f} \qquad (2)$$

where Y is the semidiameter of the circular entrance pupil of the lens and *f* is the focal length. The validity of this equation may be seen by reference to Fig. 1, remembering that in a lens having the type of correction assumed in this paragraph, the principal planes of Gauss are in reality portions of spheres centered about the axial object and image points, respectively.

2.4 If the lens aperture is not circular, which will often occur when the iris is partly closed, the angle θ has no meaning. In such a case, we may define the effective diameter, D′, of the entrance pupil in terms of its area, A, by

$$A = \frac{\pi D'^2}{4} \qquad (3)$$

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Aperture Calibration of Motion Picture Lenses

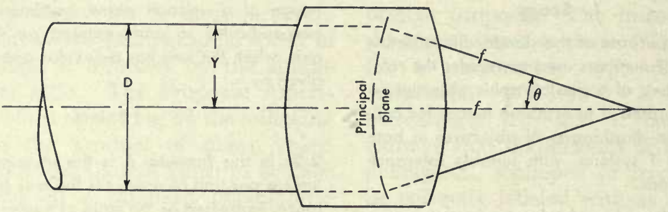

Figure 1

whence

$$D' = 2\sqrt{\frac{A}{\pi}} \qquad (4)$$

2.5 For an aplanatic lens, we may now replace sin θ by $D'/2f$, and the image illuminance equation (1) becomes

$$E = \pi \, t \, B \, (D'/2f)^2$$

whence by equation (4), we find

$$E = t \, BA/f^2 \qquad (5)$$

3. Definition of *f* Number

3.1 For a lens of the type assumed, having a circular aperture, which is perfectly corrected for spherical aberration and satisfies the sine condition, and which is also assumed to form an image in air of a very distant object, the *f* number of the lens is defined by the equation

$$f \text{ number} = \frac{f}{D} = \frac{1}{2 \sin \theta_0} \qquad (6)$$

where θ_0 is the semiangle of the cone subtended by the circular exit pupil of the lens at the point where the lens axis intersects the plane of the image of the assumed distant object, and the <u>entrance</u> pupil has a diameter D.

3.2 If the entrance pupil is not circular, this relation becomes

$$f \text{ number} = \frac{f}{D'} = \frac{f}{2}\sqrt{\frac{\pi}{A}} \qquad (7)$$

following the reasoning of Section 2.4.

3.3 If the aperture is circular, but the lens does not satisfy the sine condition, then f/D will not be equal to $1/(2 \sin \theta)$. In such a case, the *f* number of the lens is to be defined by $1/(2 \sin \theta)$ rather than by the ratio f/D. This value is chosen because both the image illuminance and the depth of field of the lens depend directly on sin θ. In such a lens, then, the marked *f* number will not be equal to the simple ratio of the focal length to the diameter of the entrance pupil.

3.4 The procedure for measuring the *f* number of a lens with a distant object is given in Section 11.

3.5 In terms of *f* number, equation (1) giving the image illuminance becomes

$$E = \pi \, t \, B/4(f \text{ number})^2 \qquad (8)$$

4. Effective and Equivalent *f* Number of a Lens Used at Finite Magnification

4.1 If a lens with a circular aperture is used to form an image at a finite magnification m, the image illuminance will, as always, be given by equation (1).

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Aperture Calibration of Motion Picture Lenses

4.2 The Effective f number of the lens, which is to be used to determine the image illuminance by equation (8), is then defined by

$$\text{Effective } f \text{ number} = \frac{1}{2 \sin \theta_m} \quad (9)$$

where θ_m changes as the magnification m increases.

4.3 For an infinitely thin lens, or for a thick lens in which the entrance and exit pupils coincide with the first and second principal planes, respectively, and in which the light beam is limited only by the iris diaphragm, the Effective f number will be related to the f number by

$$(\text{Effective } f \text{ number for magnification m}) = (f \text{ number})(1 + m) \quad (10)$$

4.4 However, many lenses cannot be regarded as being "thin," and in such cases the Effective f number at a finite magnification will not* be equal to the infinity f number multiplied by (1 + m). However, the photographer knows from long experience that he should always multiply the marked f number of a lens by (1 + m) in order to determine the Effective f number at a finite magnification m. Therefore, in order that this procedure can continue to be used, it is suggested that if a lens is designed to work at or near some particular finite magnification m, the aperture markings should be engraved with the "Equivalent f number" defined by

$$\text{Equivalent } f \text{ number} = \left[\frac{\text{Effective } f \text{ number at magnification m}}{1 + m}\right] \quad (11)$$

* For example, an afocal lens of symmetrical construction can be used as a printer or copying lens at unit magnification. The Effective f number is then equal to the f number of the half system, but since the focal length of the whole lens is infinite, no meaning can be given to the f number of the whole system. For other examples see: R. Kingslake, "The effective aperture of a photographic objective," J. Optical Soc. Am., vol. 35, pp. 518–520 (1945).

5. Definition of T Number

5.1 When lenses are marked in accordance with the f system, differences of value in the factor t of equation (1) are completely ignored, with the consequence that for a given f-setting of the diaphragms, even though correctly marked, the exposures made with different lenses may vary greatly, this variation arising from a variation in the number of component elements of the different lenses and from the large differences in the values of transmittance that exist between coated and uncoated lenses. The T system defined in this section is a new system of diaphragm graduation designed to compensate for this variation. With the T system of graduation the image illuminance in the center of the field is independent of the variations in lens structure enumerated above.

5.2 For a lens used with a distant object, the T number is defined as the f number of an ideal lens having 100 per cent transmittance and a circular aperture, which would give the same central-image illuminance as the actual lens at the specified stop opening.

5.3 Hence, for a lens with a circular aperture, following the argument of equation (8),

$$\text{T number} = \frac{f \text{ number}}{\sqrt{t}} \quad (12)$$

and for a lens with an entrance pupil of any shape and area A, the corresponding formula is

$$\text{T number} = \frac{f}{2}\sqrt{\frac{\pi}{tA}} \quad (13)$$

5.4 In practice, however, it is expected that the normal procedure will be to re-engrave the diaphragm ring on the lens at a series of

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definite T numbers, rather than to measure the T number corresponding to each of the existing marked *f* numbers.

5.5 It may be remarked again that the T number is a photometrically determined quantity, whereas the *f* number is a geometrical quantity. Since the T numbers are determined photometrically, they automatically take account of the size and shape of the aperture, the actual focal length of the lens, the lens transmittance, and any internally reflected stray light which may happen to strike the film at the center of the field (such as in a flare spot). It is implicit in the T number system of aperture markings that every lens should be individually calibrated.

5.6 For a lens designed to be used at finite magnification, the engraved T number will correspond to the Equivalent *f* number defined by equation (11).

5.7 The procedure for measuring the T number of a lens is given in Section 13.

6. Standard Series of Aperture Markings

6.1 The diaphragm ring of a lens shall be marked at every whole stop on either system. A "whole stop" is taken to represent an interval of double or half the image illuminance, corresponding to a ratio of $\sqrt{2}$ or $\sqrt{0.5}$ in the diameter of a circular lens aperture. By convention, the series of whole stop numbers to be used are accurately:

0.71, 1.00, 1.41, 2.00, 2.83, 4.00, 5.66, 8.00, 11.3, 16.0, 22.6, 32.0, ...

6.2 These marks shall be engraved on the lens as follows: 0.7, 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32. The maximum aperture of the lens shall be marked with its measured *f* number or T number, stated to one decimal place. These recommendations follow American Standard Z38.4.7–1943.

6.3 In setting the lens aperture, it is assumed that the diaphragm ring will always be turned in the closing direction, and not in the opening direction; this is to eliminate backlash effects.

7. Subdivision of a Whole Stop

7.1 If it is desired to subdivide a "whole stop" interval, we may refer to a fraction S of a stop, defined so as to yield a ratio of image illuminance R equal to 2^S or $(0.5)^S$. Then, for any given illuminance-ratio R, the corresponding fraction of a stop will be given by $S = (\log R)/(\log 2) = 3.32 \log R$. A few typical examples are given in the following table:

Fraction of a Stop (S)	Illuminance Ratio (R)
one-tenth	1.072 or 0.932
one-sixth	1.122 or 0.891
one-quarter	1.189 or 0.841
one-third	1.260 or 0.793
one-half	1.414 or 0.707
two-thirds	1.587 or 0.630
three-quarters	1.682 or 0.594
a whole stop	2.0 or 0.5

7.2 When engraving a lens, each whole stop interval may be divided into three subdivisions by dots or marks (not numbered), the dots being at "thirds of a stop," namely, <u>0.7</u>, 0.8, 0.9, <u>1.0</u>, 1.13, 1.27, <u>1.4</u>, 1.6, 1.8, <u>2.0</u>, 2.2, 2.5, <u>2.8</u>, 3.2, 3.6, <u>4.0</u>, 4.5, 5.0, <u>5.6</u>, 6.3, 7.1, <u>8.0</u>, 9.0, 10.0, <u>11.3</u>, 12.7, 14.2, <u>16</u>, 18, 20, <u>23</u>, 25, 28, <u>32</u>, ...

7.3 The reason for dividing each stop interval into three parts is so that the lens apertures will agree with the exposure-meter markings stated in American Standard Z52.12–1944, page 5. The same cube-root-of-two series is used for the Exposure Index of a film,

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see American Standard Z38.2.1–1947, page 11. One-third of a stop represents a logarithmic illumination ratio equal to 0.1, which is the transmittance of a neutral density of 0.1. The ratio of successive circular stop diameters is equal to $\sqrt[6]{2} = 1.123$.

8. Symbols

8.1 Lenses calibrated on the *f* system should bear the designation *f*/ or *f*: followed by the numerals (see American Standard Z38.4.7–1943).

8.2 Lenses calibrated on the T-stop system should bear the designation T or T— followed by the numerals.

9. Accuracy of Marking (*f* System)

9.1 The maximum opening of a lens on the *f* system shall be marked with an accuracy of ± 12 per cent of area, or ± 6 per cent of diameter.*

9.2 NOTE: Since in most factories a blanket calibration is generally used for the *f* apertures of a complete run of lenses of the same type, the smaller openings may be in error by ± 25 per cent of area, or ± 12 per cent of diameter (one-third of a stop), particularly in short-focus lenses. These figures are based on the assumption that the iris will always be closed down to the desired aperture and not opened up from a smaller aperture, to eliminate backlash effects.

10. Accuracy of Marking (T System)

10.1 Since each lens is individually calibrated, an accuracy of one-sixth of a stop (10 per cent in illumination or 5 per cent in diameter) becomes entirely possible throughout the whole range of the diaphragm scale. This is assuming that the diaphragm is always closed down to the desired aperture and not opened up from a smaller aperture, to eliminate backlash effects.

10.2 Alternatively, the manufacturer should be prepared to guarantee this accuracy even though each stop marking may not be individually determined.

10.3 It may be of interest to indicate the approximate magnitude of this tolerance. Since 5 per cent in diameter corresponds to 5 per cent in *f* number, a lens of aperture nominally *f*/2 may be anywhere between *f*/1.90 and *f*/2.10. A lens nominally *f*/4.5 may lie between *f*/4.28 and *f*/4.72; and a nominal *f*/8 may lie anywhere between *f*/7.6 and *f*/8.4.

11. Measurement of *f* Apertures (Distant Object)

11.1 The procedure for measuring the *f* number of any lens having a circular diaphragm aperture is described in American Standard Z38.4.20–1948, paragraph 3.

11.2 If the entrance pupil is noncircular, it is necessary to measure its area. This may be done conveniently by mounting a point source

* Z38.4.4–1942 the engraved focal length of lenses for still picture photography must be within ± 4 per cent of its true value, and in Z38.4.7–1943 the measured diameter of the maximum entering beam shall be at least 95 per cent of the quotient obtained by dividing the engraved focal length by the engraved *f* number. Thus by combining these tolerances we find that the diameter of the maximum lens aperture may be in error by as much as 9 per cent. This represents an error in area of 18 per cent, or one-quarter of a stop, which is felt to be unnecessarily large for the maximum aperture. The proposed tolerance on aperture marking for motion picture objective lenses allows less latitude than that provided for still picture camera lenses by Sectional Committee Z38 (Photography), because of the stricter requirements in cinematography on the same continuous length of film using different lenses.

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of light such as a small hole in front of a lamp bulb, or a 2-watt zirconium lamp, at the rear focal point of the lens, and allowing the light beam which emerges from the front of the lens to fall upon a piece of photographic material. After processing, the recorded area is measured with a planimeter and applied in equation (7). If the lens is too small for this procedure to be employed, it may be placed in a suitable telecentric projector working at a known magnification (a workshop profile projector is suitable), the back of the test lens being towards the source of light. The entrance pupil then will be projected onto the screen of the projector at a known magnification, whence its area can be determined with a planimeter.

12. Measurement of f Apertures (Near Object)

12.1 To measure the Effective *f* number of a lens when used with a near object, it is necessary to determine the angle θ in equation (9). This may be done by using a point source of light at the correct axial object position, and measuring the diameter of the emerging beam at two widely separated planes a known distance apart. A simple computation will enable the semicone-angle θ to be determined.

12.2 The Effective *f* number is defined by $1/(2 \sin \theta)$; and the Equivalent *f* number for engraving on the lens barrel will then be equal to the Effective *f* number divided by $(1 + m)$, where m is the image magnification. (See Section 4.4 above.)

13. Photometric Calibration of a Lens

13.1.1 Since T-stops are based on a measurement of the illumination produced by the lens at the center of the field, it is first necessary to define the latter term. For the purpose of illumination or flux measurements, the term "center of the field" shall be taken to mean any area within a central circle approximately 3 mm in diameter for 35mm or 16mm frames, or 1.5 mm in diameter for 8mm frames.

13.1.2 The light used in making the determination shall be white,* and the sensitivity characteristic of the photoelectric receiver shall approximate that of ordinary panchromatic emulsion.† It is considered that these factors are not at all critical and no closer specification than this is necessary. Obviously errors will arise if the lens has a strongly selective transmission, but such lenses would be undesirable for other reasons.

13.1.3 The incident light shall fill a circular field whose angular diameter is no more than 10 degrees in excess of the diagonal of the intended angular field of the lens itself. During measurement, the light shall traverse the lens in the direction ordinarily employed in photography.

13.1.4 The lens should be carefully examined before calibration to ensure that there are no shiny regions in the barrel which would lead to flare or unwanted stray light, since this would vitiate the measurements badly. The lens surfaces should be clean.

13.2 Corner-to-Center Ratio. Having calibrated the stop markings of the lens on the T system by one of the methods to be described, the observer may, if desired, determine in addition the ratio of corner illumination to center illumination, at full aperture and

* Specifically a tungsten filament lamp operating between 2900 and 3200 degrees Kelvin.

† A suitable cell is one having an S-3 surface, combined with a Corning 9780 glass filter about 2.5 mm thick.

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preferably at other apertures also. For this purpose the 3-mm (or 1½-mm) hole shall be used first at the center of the field, and then moved outwards until its rim is touching the top and side limits of the camera gate. This distance is shown in Table I.

Table I

Gate, Mm	Radial Shift of Hole, Mm
35 (16.03 × 22.05)	11.5
16 (7.47 × 10.41)	4.5
8 (3.51 × 4.80)	2.0

13.3 Extended-Source Method of T-Stop Calibration (distant object).

13.3.1 This method of lens calibration has been described by Gardner[13] and Sachtleben,[9] the underlying theory being given by McRae.[4] It is based on filling the lens with light from an extended uniform source, and placing a metal plate in the focal plane of the lens with a 3-mm hole (or 1.5-mm for 8-mm film) at its center. The light flux passing through the hole is measured by a photocell arrangement. This flux is then compared with the flux from the same source passing through the same hole from an open circular aperture of such a size and at such a distance from the plate that it subtends the desired angle θ referred to in equation (2) above. The greatest care is necessary to ensure that the extended source is really uniform, and also constant throughout the measurements. The open circular aperture is used as the "ideal lens with 100 per cent transmittance" referred to in Section 5.2.

13.3.2 It should be noted that this procedure measures the T-stop Aperture Ratio of the lens directly, regardless of whether or not the lens is aplanatic.

13.3.3 In practice, the photocell reading for each whole T-stop number is first determined for a series of open apertures, at a fixed distance from the plate. The lens is then substituted for the open aperture with the 3-mm hole accurately in its focal plane, and the iris of the lens is closed down until the photocell meter reading produced by the lens is equal to each of the successive open-hole readings. The full T-stop positions are then marked on the diaphragm ring of the lens. The intermediate third-of-a-stop positions may be found with sufficient accuracy by inserting a neutral density of 0.1 or 0.2 behind each open aperture in turn and noting the corresponding photocell readings.

13.3.4 The following table of aperture diameters may be useful. They are based on a distance of 50 mm from aperture to plate. (It is important to remember the difference between sine and tangent, and that the aperture diameter is not found merely by dividing 50 mm by the T number.)

Table II

Desired T Number	Value of θ = Cosec^{-1} (2 × T number), Degrees	Diameter of Aperture = 100 tan θ, mm
0.5	90	∞
0.71	45	100
1.00	30	57.74
1.41	20.708	37.80
2.00	14.478	25.82
2.83	10.183	17.96
4.00	7.181	12.60
5.66	5.072	8.88
8.00	3.583	6.26
11.31	2.533	4.42
16.00	1.791	3.12
22.63	1.266	2.21
32.00	0.895	1.56

13.3.5 A single set of apertures is sufficient to calibrate lenses of all focal lengths, since the only factor involved is sin θ, and that is

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fixed by the aperture used. The apertures should be bevelled to a sharp edge, and well blackened on both sides.

13.3.6 The extended source should be uniformly bright over its useful area to within ± 3 per cent. (This can be tested with a suitable telephotometer, or a small hole in an opaque screen can be moved around in front of the source, and any consequent variations in photocell reading noted.) The source conveniently may be a sheet of ground glass covering a hole in a white-lined box containing several lamps mounted around the hole and shielded so that no direct light from the lamps falls on the ground glass itself.

13.3.7 The photocell receiver conveniently may be of the phototube type with a simple direct-current amplifier.* Care must be taken to ensure that the phototube sensitivity and the line voltage do not change between making readings on the open aperture and on the lens itself; to guard against this, some convenient turret arrangement is desirable with the lens on one side and the open aperture on the other so that the two may be interchanged and compared immediately with each other by merely turning the turret.

13.3.8 To measure the corner-to-center illumination ratio, then lens is set in position and the 3-mm hole and the photocell are displaced laterally by the desired amount. The photocell reading is noted at axial and corner positions, and the corresponding light ratio found from a calibration curve of the photocell meter.

* Suitable systems are the "Electronic Photometer" model 500 (Photovolt Corporation, 95 Madison Ave., New York, N. Y.), and the "Magnephot" (W. M. Welch Scientific Co., 1515 Sedgwick St., Chicago, Ill.). It is felt that a barrier-layer cell, although desirable for reasons of simplicity, has insufficient sensitivity for accurate determinations of the smaller apertures unless a galvanometer of exceptionally high sensitivity is employed.

13.4 Collimated Source Method of Lens Calibration.

13.4.1 This method has been described by Daily [11] and Townsley,[14] the underlying theory being embodied in Section 5 above. Light from a small source (a 5-mm hole covered with opal glass and strongly illuminated from behind) is collimated by a simple lens, or an achromat if preferred, of about 15 inches focal length and 2 inches aperture. This gives a collimated beam which will be focused by the test lens to form a small disk of light in its focal plane. This circle of light will be less than the prescribed limit of 3-mm diameter for all lenses under 9 inches in focal length. Uniformity of the collimated beam can be checked by moving a small hole in an opaque screen across the beam, and any variations in the photocell reading noted.

13.4.2 For the comparison unit, an open aperture is used, of diameter equal to the focal length of the lens divided by the desired T number. This aperture is first mounted in front of an integrating sphere with the usual photocell detector, and the light from the collimator is allowed to enter the aperture. The aperture plate is now replaced by the lens, the iris diaphragm is closed down to give the same photocell reading, and the T-stop number is engraved on the iris ring. The intermediate thirds of stops can be added by using 0.1 or 0.2 density filters as in the method of Section 13.3.3.

13.4.3 To guard against drift and line-voltage variations which might occur between the readings on the comparison aperture and on the lens, it is convenient to leave the known standard aperture in place in front of the sphere, and to insert the lens into the beam in

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such a position that the little image of the source falls wholly within the standard aperture. The meter reading should then remain the same no matter whether the lens is in or out of the beam. A second plate with a 3-mm aperture should be placed over the comparison aperture while the lens is in place to stop any stray light which may be reflected from the interior of the lens.

13.4.4 It should be noted particularly that if this method is used, the focal length of the lens must be measured separately, and a suitable set of open apertures constructed for use with it. However, by suitable devices, one single set of fixed apertures may be used for all lenses, as described by Townsley.[14]

13.4.5 It should also be noted that this procedure measures f number as the ratio of f/D, and the measurement is thus influenced by the state of correction of the lens in regard to spherical aberration and sine condition.

13.4.6 The corner-to-center ratio at any desired aperture can be conveniently determined by simply rotating the lens through the desired field angle ϕ and comparing the photocell reading with its value for the lens axis. The light-flux ratio can then be read off a calibration curve for the photocell system, and converted to the desired corner-to-center illumination ratio by multiplying it by $\cos^3\phi$. (Note that this procedure will be correct only in the absence of distortion, but no motion picture lens is likely to have enough distortion to cause any significant error.)

13.5 T-Stop Calibration at Finite Magnification.

13.5.1 To use the extended source method (see Section 13.3), it is only necessary to mount the metal plate at the desired image distance from the lens instead of placing it in the focal plane. The open apertures used for comparison must be calculated to have an opening corresponding to the desired Equivalent f number multiplied by $(1 + m)$. This is because we are really comparing the illuminance given by the lens with the Effective f number of the open hole, but the engraving must be done at each standard step of the Equivalent f number (see Section 12.2.)

13.5.2 The collimated source method cannot be used to calibrate a lens at finite magnification.

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Proposed American Standard

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NOT APPROVED

International Standardization

By F. T. BOWDITCH, SMPTE Engineering Vice-President

ON LAST JUNE 9, 10 and 11 at Columbia University, the first meetings of Technical Committee 36 on Cinematography of the International Organization for Standardization were held. This is the standards group charged with the preparation of world standards in fields of cinematography, under the Secretariat of the American Standards Association. A following report by Henry Kogel will give details of the several subjects discussed. We will consider here our general impressions of this very interesting event.

Contrary to the final feeling of a worth-while job well done, those of us from the United States who took part in this affair did so largely from a sense of duty to the Secretariat responsibilities of the ASA. None of us had any previous experience in international deliberations of this sort, and we were uncertain as to how much could be accomplished. At the end of three days of close association with our foreign colleagues, however, the opinion was enthusiastically unanimous that the meetings had been very much worth while; the only complaint to come to my attention concerned the schedule, in which only two days had been allocated to TC36. Arrangements were made on the second day to continue for a third, and everyone felt that a full week could have been spent with profit; as a matter of fact, with a series of group meetings burning the midnight oil on both Monday and Tuesday evenings, a good week's work was actually crowded into those three days.

In addition to the U.S. delegation, the meetings were attended throughout by representatives of Canada, France, Germany and the United Kingdom. A Belgian representative joined us occasionally, and a space was continually reserved for the U.S.S.R., whose delegates were somewhere about, but scheduled uncertainly between cinematography and other concurrent meetings. The Russians never did visit us, which was a matter for some disappointment curiosity-wise, although the complication of a second translation of all remarks would undoubtedly have slowed our progress. As it was, the remarks of the delegate from France, M. Jean Vivié, were always made in his native tongue, with frequent pauses for translation into English; while the remarks of all other delegates in English were translated into French for M. Vivié. This would at first seem to delay things immeasurably, but we were fortunate in having a most capable interpreter, Mr. L. Foy, whose repertoire included perhaps ten languages any one of which he could translate extemporaneously and unhesitatingly into any other. He soon developed an amazing knowledge of motion picture technology and so operated with the highest efficiency.

The formal meetings were opened on Monday morning, June 9, by Vice-Admiral G. F. Hussey, Jr., Managing Director of the ASA. He introduced D. E. Hyndman, who delivered the welcoming address, calling attention not only to the great importance of international standards in facilitating world trade, but pointing out the forthcoming significance of television as an international force, and predicting a growing interest of TC36 in world

standards for this specialized form of motion pictures.

Dr. L. Knopp, delegate from the United Kingdom and President of the British Kinematograph Society, then proposed that the writer be elected as Chairman of the meeting, which was promptly done. This responsibility was approached with some uncertainty, but was soon exercised with greater confidence as the fine cooperative spirit of the delegates became apparent, and as the bilingual machinery operated with much greater smoothness than we had anticipated. Mr. W. Rambal of the central ISO office in Geneva sat at the Chairman's right in the first sessions, to offer helpful advice on parliamentary matters as needed.

As things developed, the formal meetings of the whole Committee were soon abandoned in favor of a series of six Working Group meetings on as many different subjects. These were attended by all the foreign delegates and by a limited number of U.S. delegates most interested in each particular subject. Chairmanships of these Working Groups were delegated to the French, German and United Kingdom representatives, as well as to the U.S., and all were conducted in a most efficient manner. Jean Vivié of France, Dr. Leo Busch and Wilhelm Waegelein of Germany, and Dr. L. Knopp and H. L. Griffiths of England worked tirelessly and conscientiously with all these groups, till late at night on Monday and Tuesday, and starting again early each morning. Gerald Graham of Canada was also present, but only as an observer since his country is not represented as a full working member of TC36; Mr. Foy, our indefatigable translator, was ever-present to bridge the language barrier. The U.S. delegation of 20 persons, ably headed by Dr. D. R. White, chairman of ASA Sectional Committee PH22 on Motion Pictures, had a somewhat easier time of it, with a different small number at each group meeting. The many months of preparation by PH22 and by the several Engineering Committees of SMPTE proved exceedingly helpful here, as did the active participation of The Motion Picture Research Council. W. F. Kelley of the Council cooperated in all the group meetings, giving much helpful advice where motion picture studio considerations were involved.

Minutes of each meeting and copies of all resolutions were prepared in time for distribution at the next session, mimeographed both in French and in English. This required that an English version be prepared at the earliest possible moment. Henry Kogel, Staff Engineer of SMPTE, was of much service here, cooperating with J. W. McNair, Miss Virginia Kelly and Miss Carolyn Locher of ASA to get all of our deliberations correctly recorded.

At the final formal meeting of TC36 on Wednesday afternoon, it was agreed that all the Working Groups should be continued on a more permanent basis, under the chairmanships first assigned. It seems certain that cooperation via correspondence will now be very much more effective than before these personal acquaintanceships were made. Certainly the foreign delegates gave every evidence of a high degree of competence and sincerity, and in all instances were very well prepared to discuss the various matters on the agenda.

The U.S. delegates had also come well prepared and with open minds, as witness the agreement to recommend as a World Standard a picture-to-sound separation of 21 frames for 35mm film. The present American Standard specifies this distance to be only 20 frames, and any change at first seemed to be an altogether futile attempt to change a well-established U.S. practice. It soon developed, however, that the U.S. practice is in fact to use the 21-frame separation: projectors are threaded at 20-frames, but the studios adjust the sound-to-picture separation on the film to give

synchronization to an observer seated 50 ft from the screen. Some years ago this 21-frame French proposal was received in the U.S. via correspondence, and circulated here for comment over a period of months, with unanimous agreement that it would be impractical for the U.S. to change. A half-hour's direct conversation with the French, English and German delegates brought out the fact noted above, that the U.S. has been using this proposal all along — only the standard itself needs to be changed to bring everything into agreement!

The opportunity of serving as the chairman of this first meeting of ISO/TC36, although approached with some uncertainty, is looked back on with deep appreciation. This was a most heartening experience, and all who contributed to these meetings have the right to feel that the work of TC36 has now been given a most effective start. When men of good purpose sit down together and talk things over, much can be accomplished, as witness the following report by Henry Kogel. We are proud and happy to have played a part.

Agenda and Accomplishments of ISO/TC 36 Meeting

By HENRY KOGEL, SMPTE Staff Engineer

THE PRECEDING REPORT on international standardization by F. T. Bowditch has clearly outlined the general aspects of the three-day meeting, June 9–11, of Technical Committee 36 on Cinematography of the International Organization for Standardization (ISO/TC 36). It is, therefore, the intent to present here only the specific details considered and the concrete results to date.

The draft agenda was considered first, then amended slightly. It is given below in its final form along with the Working Group associated with each item.

1. Welcoming Remarks, D. E. Hyndman
2. Introduction to Those Present, G. F. Hussey, Jr.
3. Opening Remarks by the Chairman, F. T. Bowditch
4. Approval of Agenda
5. Review of Scope
6. Dimensions of Raw Stock — Work Group 1, chaired by D. R. White, United States
7. Definition of Safety Film — Work Group 2, chaired by Leslie Knopp, United Kingdom
8. Emulsion and Sound Record Position in Cameras and Projectors — Work Group 3, chaired by Leo Busch, Germany
9. Dimensions and Location for Sound Records and Scanning Area — Work Group 4, chaired by Malcolm Townsley, United States
10. Location and Size of Picture Apertures in Cameras, Projectors and Printers — Work Group 5, chaired by Jean Vivié, France
11. Standards Relative to Projection Halls — Work Group 6, chaired by Leslie Knopp, United Kingdom
12. Review of Program of Work

In the discussion on scope, the French delegate proposed a new version. Modifications were offered and the following scope was approved for submittal to letter ballot of TC36.

"The committee shall formulate definitions, dimensions, methods of measurement and test, and performance characteristics related to materials and apparatus used in silent and sound motion picture photography, in sound recording and reproduction and in laboratory work, also, standards relating to the installation and characteristics of projection and sound reproduction equipment.

"Collaboration is to be established with all other Technical Committees working on related questions and especially with the Committees ISO/TC 42 — Photography and ISO/TC46 — Documentation."

The previous scope is offered for comparison purposes:

"The formulation of definitions, dimensional standards, methods of test, rating and performance characteristics of materials and devices used in silent and sound motion picture photography and in sound recording and processing and reproduction in connection therewith. Collaboration is to be established with other Technical Committees, especially with ISO/TC46 — Documentation, in work on photographic reproduction."

After providing each member nation an opportunity to make a general statement on agenda items 6–11, the chairman appointed Work Group chairmen and the remainder of the sessions were devoted primarily to the detailed considerations of the six Work Groups. The conclusions reached in each Group are presented below.

Dimensions of Raw Stock

It was unanimously agreed to recommend to ISO/TC36 that the secretariat prepare a Draft ISO Proposal for letter ballot action of all members on Cutting and Perforating Dimensions for 35mm Motion Picture Positive Raw Stock to be based upon the American Standard Z22.36-1947 with the changes indicated below.

(1) Dimension A to read
$1.378 {+0.000 \atop -0.002}$ inch $35.00 {+0.00 \atop -0.05}$ mm

(2) Dimension L to read
18.70 ± 0.15 inch 475.00 ± 0.40 mm

(3) Dimension R to read
0.50 millimeter, provided that the secretariat finds that this is the proper way to express correspondence with 0.020 inch.

(4) Dimension G to be expressed as shown in the French Standard NFS 24-003 with the drawing of the type given therein but with the format altered to show lines referring to bottom edges of perforations rather than center lines.

(5) The footnotes in Z22.36-1947 indicated by an asterisk and a dagger, and the appendix, are to be deleted.

(6) Dimension symbol "I" to be changed to "F."

It was also unanimously agreed to recommend to ISO/TC36 that the secretariat prepare two Draft ISO Proposals on Cutting and Perforating Dimensions for 16mm Silent and Sound Motion Picture Negative and Positive Raw Stock, based upon the American Standards Z22.5-1947 and Z22.12-1947, with the following changes:

(1) Dimension A to read
0.628 ± 0.001 inch $15.95 {+0.03 \atop -0.02}$ mm

(2) The drawing used to show dimension G in Z22.5 to follow French practice paralleling the 35mm presentation adopted from the French Standard NFS 24-003, Dimensions of 35mm Positive Raw Stock, With Positive Perforations.

(3) Dimension symbol "I" to be changed to "F" in Z22.5.

(4) Omit notes indicated by asterisk and dagger.

(5) Omit appendix.

(6) Add a new note reading "Experience shows that it is common for film to expand when exposed to high relative humidity. Allowance should be made for this factor in equipment design and in no case should the equipment design fail to accommodate film width of 0.630 inch, 16.00 mm."

A specification for film thickness was discussed by the working group but no agreement was reached. The matter was left for further discussion and study.

Definition of Safety Film

It was initially agreed that an international standard for the definition, test and identification of safety film should be established.

One of the U.S.A. delegates believed it would be desirable that any ISO standard for 32mm, 16mm and 8mm motion picture film should stipulate the use of a safety base only. The proposal appeared to raise national statutory and legal questions which would call for investigation and consideration.

The working group noted that the research which had been conducted in the United Kingdom had established a simple form of test which might replace the more elaborate laboratory tests of the current American Standard Definition for Motion Picture Safety Film, Z22.31-1946. A demonstration of the apparatus was given and the members thought the United Kingdom test worthy of study. The United Kingdom undertook to prepare and circulate working drawings and particulars to enable each country to make its own apparatus and carry out confirmatory tests.

France and Germany, however, desired the earliest possible establishment of an international standard and suggested that the current American Standard, which was virtually a reproduction of the ISA proposal of 1936, should be considered for adoption by the ISO for a three-year period. While not seeing any urgent need for this, the United States representatives said they would not wish to oppose the adoption of this course. The United Kingdom delegates had no power to commit their country but only to express the view that the 1936 ISA proposal was too elaborate, was out-of-date and the time was ripe for a new specification to be formulated.

It was understood that the ISO was willing to circulate ISA proposals and recommendations which could be used nationally pending the agreement on an international standard.

Agreement was finally reached that the Definition for Motion Picture Safety Film, Z22.31-1946, be submitted to ISO/TC36 for letter ballot action.

Emulsion and Sound Record Positions in Cameras and Projectors

The working group agreed to recommend to ISO/TC36 that the secretariat prepare a Draft ISO Proposal incorporating the technical content of the American Standards listed below with the modifications indicated:

Emulsion and Sound Record Positions in Camera for 35mm Sound Motion Picture Film, Z22.2-1946,

Emulsion and Sound Record Positions in Projector for 35mm Sound Motion Picture Film, Z22.3-1946,

Delete paragraphs 2 and 3, reference to guided edge and footnote. Add identification of sound record (shaded area).

Emulsion Position in Camera for 16mm Silent Motion Picture Film, Z22.9-1946,

Emulsion Position in Projector for Direct Front Projection of 16mm Silent Motion Picture Film, Z22.10-1947,

Emulsion Position in Camera for 8mm Silent Motion Picture Film, Z22.21-1946,

Emulsion Position in Projector for Direct Front Projection of 8mm Silent

Motion Picture Film, Z22.22-1947,
Delete paragraph 2 and footnote.

Emulsion and Sound Record Positions in Camera for 16mm Sound Motion Picture Film, Z22.15-1946,
Delete paragraph 2, footnote and reference to guided edge. Also delete paragraph 3, but the technical substance of this paragraph is considered suitable for incorporation in a more suitable place. Add identification of sound record (shaded area).

With regard to Z22.16-1947, the working group decided that at present it did not seem desirable to consider this for international adoption since prints were made with the emulsion position on either side and there was little likelihood of universal acceptance of a single standard at this time.

The working group discussed at some length the question of projection speed of 24 or 25 frames per second, but did not reach any decision.

Dimensions and Locations for Sound Records and Scanning Area

Work Group 4 recommended that five American Standards be prepared by the secretariat for circulation as Draft ISO Proposals, two without change:

Z22.69-1948, Sound Records and Scanning Area of Double-Width Push-Pull Sound Prints, Normal Centerline Type,

Z22.70-1948, Sound Records and Scanning Area of Double-Width Push-Pull Sound Prints, Offset Centerline Type;

and three with the modifications indicated below:

Z22.40-1950, Dimensions and Locations for Sound Records and Scanning Area of 35mm Sound Motion Picture Prints

(1) The distance from the edge of the film to the centerline of the sound record shall be changed from 6.17 ± 0.02 mm to 6.19 ± 0.02 mm (0.244 ± 0.001 in.).

(2) The distance from the edge of the film to the inner edge of the printed area shall be changed from 7.75 ± 0.05 mm to 7.83 ± 0.05 mm (0.308 ± 0.002 in.). (This change was proposed by the French delegate on the basis that difficulties are being experienced in France with a white line between sound track and picture printed areas. The United Kingdom delegation reserved judgment on the dimension in (1) and (2) above, but approves the circulation of the draft.)

(3) In the specification "Distance between sound and corresponding picture" change "20 ± $\frac{1}{2}$ frames" to "21 frames ± $\frac{1}{2}$ frame." (When the distance from the center of the projector gate to the sound scanning point is 20 frames, the picture and sound will be in synchronism for an observer at a distance of 50 feet, and with French practice, which is based on a measured distance of 21 frames between picture and sound on the film itself, and therefore allows for synchronizing the picture to suit an average audience size.)

(4) Delete the third footnote.

(5) Delete the dimension and all reference to the height of the scanned area.

Z22.41-1946, Sound Records and Scanning Area of 16mm Sound Motion Picture Prints

(1) Change the tolerance on the width of the sound record for full width variable-density record from 0.080 ± 0.001 in. to 0.080 $^{+0.004}_{-0.001}$ in.

(2) Delete the present footnote.

(3) Add a new footnote reading: "The width of the 16mm sound record is derived by reducing the corresponding 35mm dimensions by a ratio of 1.2 to 1.0 in.

(4) Add a new paragraph: "Distance between sound and corresponding picture — the sound record shall pre-

cede the center of the corresponding picture by a distance of 26 frames ± ½ frame."

PH22.86, Dimensions for 200-Mil Magnetic Sound Tracks on 35mm and 17½mm Motion Picture Film (a Proposal well on its way to becoming an American Standard).

(1) Revise the drawing and dimensions to show a dimension from the outer edge of the sound record area to the edge of the film 6.0 ± 0.05 mm (0.236 ± 0.002 in.) on each edge of the film, and delete all other dimensions and all reference to the track in the center of the film, renumbering Track 3 to Track 2. (The United Kingdom delegation was unable to associate itself fully with this resolution as being the best solution of the current practices in America, France and in the United Kingdom, and offered alternative proposals (which, however, were not accepted) on the dimension of 0.345 inch ± 0.005 or 0.345 inch ± 0.006, as the location of the centerline of the sound record relative to the edge of the film.)

(2) Delete paragraph 7.

(3) Add a note to Paragraph 6: "When the film is turned end for end, Track 2 occupies the position of Track 1."

Location and Size of Picture Apertures in Cameras, Projectors and Printers

The chairman of Group 5 has not as yet submitted the report of the conclusions reached by his group. This information will be published in a future issue of the *Journal* as soon as it is received.

Standards Relating to Projection Halls

The members of Work Group 6 had each presented at their meeting a summary of the requirements and values in their published and draft standards on the subject of screen brightness. Reference was also made to the resolution of the CIE (International Commission on Illumination) at its meeting in Stockholm in 1951. It was agreed to restrict discussion to enclosed cinema auditoriums.

The members noted that the various countries were now giving consideration to such factors as: the screen brightness measurement made from any seat in the auditorium, the diversity of luminance between the side and center of the screen, interference of luminance by stray light, the method of measurement and the type of instruments to be used. The views of the delegates on these questions were diverse and in some of the countries research and investigation were still proceeding.

Differing opinions were also expressed as to the desirability of adopting the luminance range and the diversity factors of the CIE Stockholm meeting. It was noted that the United States and the United Kingdom expressed their luminance values in foot-Lamberts while France, Germany and the CIE resolution expressed values in metric units. It was also noted that, notwithstanding these divergencies, the quantitative difference in the various specifications and in the CIE resolution were not great.

In view of the research and investigation still proceeding in the various countries, it was the general consensus that it was not opportune at the present ISO/TC36 meeting to attempt to draft an ISO proposal. It was agreed, therefore, that each country should proceed with its own investigations and revision of its own standards, if desired, and that there should be a postal exchange of information between the countries, so that at the next meeting of ISO/TC36 the present discussions might be resumed and an ISO proposal drafted.

The working group regretted that time did not permit any discussion on the remaining subjects such as projection rooms and projection screens listed under item 11 of the agenda.

Organization of the San Francisco Subsection

This brief outline of the organization of the San Francisco Subsection of the Society may be of interest and assistance to similarly situated groups in other localities.

The San Francisco Subsection began as the expression of a desire of a number of the individual members in the Bay Area to have some form of local activity and participation in the affairs of the Society. The Conventions held alternately in Hollywood provided some advantage but in general most of the members gained from their membership only the published *Journal*.

Many informal discussions had been held during 1951 regarding the practicability of setting up some form of local group and these culminated in the formation of the present organization. Edwin W. Templin and Dr. Charles R. Daily were particularly helpful in presenting our plan to the Board of Governors and securing its approval. The Constitution of the Society does not specifically provide for subsection organization but neither does it forbid it, and, by the latter liberal view, the San Francisco group was authorized to form the subsection of the Pacific Coast Section at the meeting of October 13, 1951.

Upon receiving formal notice of this action, all of the members of the Society residing in the Bay Area were notified by mail and the organizational meeting of the subsection was held November 30, 1951. Dr. Daily addressed the group at this meeting and acted as chairman, representing the parent section. Election of officers resulted in the following roster for 1952:

Chairman, Paul A. Williams
Vice-Chairman, William A. Palmer
Secretary-Treasurer, George Mathiesen
Program Chairman, John B. Steiger

During the first half of the year the subsection has held three meetings, the programs of which were as follows:

February 21: "Production of a Pilot Kinescope for the *Standard Hour*" presented by a panel consisting of Warren Andersen, A. F. Michaelis and W. A. Palmer.

April 17: "TV Picture Sizes," a tape recording of papers and discussion from a meeting of the Pacific Coast Section in Hollywood.

May 22: "Creative Directions in Color Photography" presented by Ralph Evans of Eastman Kodak Company.

Attendance at these meetings has been from 20 to 50, which, although perhaps not too impressive, represents a large percentage of the total group membership.

Although there was no expressed plan of suspending meetings during the summer, the usual circumstances have conspired to prevent or delay the fulfillment of our anticipated plans. Meetings are planned for the fall and winter and we hope to end the first year of operation at a peak of activity.

The effect of an actively functioning local group on membership recruiting activity has been very gratifying. It is conservatively estimated that we have added twice the number of new members since beginning local operation compared with the previous like period. It is also interesting to note that, although the present interest in the television field has probably encouraged activity and increased our local membership, there has been enthusiastic interest among members in the motion picture industry.

Whether or not the time is ripe for the San Francisco group to plan on an early change to independent section operation cannot yet be determined. At the end of this year officers will be elected for the coming term and that question fully discussed.

We have not been as active as we had hoped but we are certain that our activity will increase rather than diminish. It would be a real help if more assistance could be provided in securing program material. The experiment we made with the use of tape recorded material was considered successful but for some reason or another we have had some difficulty in arranging for additional recorded program material. It is noted that the IRE Audio Group has set up a similar plan with a

central tape exchange and this method might be worth consideration.

The Subsection expenses are a very minor consideration, for, aside from the cost of mailing program announcements, no other expense has been incurred. The parent Section advanced a sum sufficient to cover this and other incidental expense. Meeting places, projection or reproduction equipment and preparation of meeting notices have been provided by various members through the courtesy of their business connections.

We are firmly of the opinion that the Society as a whole and its individual members have much to gain by establishment of other subsections. The time has long since passed when New York and Hollywood represented a concentration of motion picture and television activity to the exclusion of all other areas. The Society should provide some service to its members in other areas beyond the publication and distribution of its *Journal* and we are of the opinion that the organization plan we have followed provides a means toward that end. — *Paul A. Williams*, 341 Hazelwood Ave., San Francisco 12, Calif.

Book Review

Color in Business, Science and Industry

By Deane B. Judd. Published (1952) by John Wiley, 440 Fourth Ave., New York 16. 401 pp. 106 illus. 6 × 9¼ in. Price $6.50.

Here is a most useful and valuable book by Dr. Deane B. Judd, Chief of the Colorimetry Unit of the National Bureau of Standards. During his twenty years with the Bureau he has come in contact with hundreds of industrial colorimetric problems. This book reflects his great experience along these lines as well as the many contributions which Dr. Judd has made to the science of color. It is an ambitious undertaking to attempt a book on color that would appeal to business, to science, and to industry; but through Dr. Judd's long association with all three groups he has succeeded remarkably well.

The businessman may enjoy the very readable Part I with its emphasis on the eye, the customer, and what the customer sees. He may then profit by scrutinizing the excellent introductions and summaries in each of the other sections in the remainder of the book, leaving the study of the technical details in these sections to others. However, industrial engineers and research workers in the field of color will find the entire work valuable because of the fusion of the practical problems with their theoretical aspects and the engineering or technical solutions to them. In fact, the book is mainly directed at this group, and excels any other work in telling the story of the tools and techniques available to workers in the field.

The book is divided into three parts. Basic facts pertaining to the science of color are given in Part I. Here the author explains the functioning of the eye, the characteristics and effects of abnormal vision, the methods of color matching, and the aspects of color. It is clearly shown that perception of color bridges many sciences. This is, however, treated in practical fashion as shown by the section titles: "Chemical — Pigments and Dyes," "Physical — Radiant Energy in the Spectrum," "Psychological — The Customer's Angle," and "Psychophysical — How to Predict What the Average Customer Will See."

Part II, entitled "Tools and Techniques," comprises by far the largest portion of the book. Here are set down the principles and practices for spectrophotometry, colorimetry and colorimeters, reproduction of pictures in color, color standards, uniform color scales, and color languages. Some 130 pages are devoted to these last three. He gives an unusually fine presentation with clear explanations and evaluations of available sets of color standards for specifying or matching color, such as the Munsell Book of Color, the Villalobos Colour Atlas, the Color Harmony Manual, and other systems. Color

cards or standards provided by various segments of industry such as the textile, printing ink, or paint industries, are also described. The glossary of color terms at the end of Part II will be most useful in that it collects in one place the terms and definitions for the most important color concepts used in American industry.

Part III, "The Physics and Psychophysics of Colorant Layers," thoroughly explores techniques for determining or forecasting the gloss and opacity or hiding power of colored layers. The major portion of this part is given over to the Kubelka-Munk analysis as applied to dyed textiles, paints, papers or pigmented plastics. Several mathematical tables necessary for such analytical solutions are included in the appendix which should prove useful to those interested in these materials.

There is an excellent selection of references which includes the important work in the field for those who will wish to pursue the subject further, and also a fine index.

Members of the SMPTE may be particularly interested in the section entitled "Reproductions of Pictures in Color," in which Dr. Judd outlines the general problem and also demonstrates by a practical example the use of the CIE tristimulus values and the color triangle to select practical working primaries, and thence to the determination of camera sensitivities for a typical color television system. This reviewer was particularly impressed by Dr. Judd's reasonable approach to the old question of the importance of art versus science in color reproduction. To quote:

"An important question in reproduction of pictures in color is color fidelity — how faithfully the colors of the original scene are reproduced. This is not the whole of the problem of producing pictures that the public will like. We know too little about what makes us see objects and people from the mosaic of colored patches presented to the eye from real scenes to state with confidence that a completely faithful reproduction (not yet achieved, by the way) would always look good. In fact, there are some who take the position that perfect color fidelity usually leads to poor pictures and should be avoided on purpose. They say that intentional systematic deviations from fidelity can make the picture better than the original itself. This is adding art to science. But even if you intend to try to improve on the original scene, it is a great help to have a faithful reproduction to start with. You could not get very far with intentional improvements if the basic color fidelity of the picture was so poor that it would not yield any reds, for example, in the picture, or so poor that greens in the original scene were rendered as reds in the picture. So, reasonably faithful reproduction of colors must be built into any reproduction system, even if the final aim is to improve artistically upon the original scene by intentional deviations from color fidelity."

With the increasing emphasis on color in motion pictures and television, an understanding of this concept is important.

This book is highly recommended to all interested in color and its industrial applications.—*L. M. Dearing*, Technicolor Motion Picture Corp., 6311 Romaine St., Hollywood 38, Calif.

Journal on Microfilm

Microfilm editions of the *Journal* of the SMPTE are now available to members and subscribers from University Microfilms, Ann Arbor, Mich., which records more than 700 periodicals. *Journal* Volumes 54 and 55 (1950) are priced at $4.15 and Volumes 56 and 57 (1951) cost $4.00 (this is the year that the *Journal* switched to the two-column format, with a saving in pages). If there were enough demand for it, University Microfilms would make positives for the years 1941–49. The present price for such positives is about a half cent per page, but this would be reduced with a larger number of customers to share the cost of the negatives. Readers may address inquiries to University Microfilms, 313 North First St., Ann Arbor, Mich.

Members and the Journal Overseas

Echoes of the impact of the SMPTE and the *Journal* come back to us from overseas now and then — and we should record them, just as we have been able earlier in this *Journal* to record the exchange of bases for international standardization.

A recent letter from Vernon Jarratt, Manager of Mole-Richardson (Italia), Rome, prompts some quotation and notation about the Society in Italy:

"What I have noticed is the considerable increase in the circulation of the *Journal* in the three years that I have been a member. This is probably more noticeable to someone like myself who is in constant touch with the various technical heads than visible in your list of subscriptions, as a good deal of the 'circulation' is the literal circulation of a copy that travels from office to office and from desk to desk.

"When Mole-Richardson opened here in 1948 the technical side of the industry was in a pretty primitive state all around, as indeed is obvious to anybody who, from a purely technical point of view, considers the films such as *Rome Open City*, *Four Steps in the Clouds*, *Paisà*, and the other films with which Italy first made its postwar name. This was partly due to destruction and looting during the war, and partly to the Fascist policy of autarchy which threw the Italian industry very much back on its own resources.

"One incidental result of this was rather amusing. When we brought in the first 'Brutes' in 1949 most cameramen refused to touch them, insisting that they could manage quite well with the 150-amp arcs to which they were already accustomed. One or two of the more enterprising (who, incidentally and not surprisingly, are also members of the Society) broke the ice, however, and the rest rapidly followed. The difference was very noticeable when, last year, we introduced Compact Source (mercury-cadmium) equipment for the first time. Although this represents a much bigger technical difference from previously existing equipment than the Brute, which is after all only a larger carbon arc, the Compact Source equipment was accepted with much less resistance. Now, and thanks certainly in part to the *Journal*, there is a much livelier interest in technical developments."

Mr. Jarratt's letter prompted a few moments research which revealed the following thirteen members with addresses in Italy.

Baume, Alessio, Manager, 16mm, Metro-Goldwyn-Mayer, Italy. **Mail:** Via Camilluccia 71, Roma, Italy. **(A, 1947)**

Carrara, Enrico, Vice-President, Cetra Records, Corso Pesihiera 10, Torino, Italy. **(A, 1949)**

Cambi, Enzo, Consulting Engineer, Cinecitta Studios; Lecturer, National Research Council (Italy) and Leghorn Naval Academy. **Mail:** Via Giovanni Antonelli 3, Rome, Italy. **(A, 1950)**

Corradi, Amerigo, Tecnostampa, Via Albalonga 38, Rome, Italy. **(A, 1950)**

Dalle Rose, Demetrio D., Manager, Western Electric Company of Italy, Inc. **Mail:** Via Oglio 9, Rome, Italy. **(A, 1946)**

De Renzis, Francesco, Manager, Westrex Co. (Italy), Piazza Lovatelli 1, Rome, Italy. **(A, 1945)**

Innamorati, Libero, Dr. Ing., Centro Sperimentace Cinemato-Grafia. **Mail:** Via Satrico 43, Rome, Italy. **(A, 1936)**

Jarratt, C. V., Manager, Mole-Richardson (Italia), Via Dell'Arco Di Travertino, No. 57, Rome, Italy. **(A, 1949)**

Marzari, Antonio, Cameraman, Shorts Producer and Director, Veneziana Cortometraggi, S. Marco 557, Venice, Italy. **(A, 1947)**

Monteleoni, Giulio Cesare, Ispettore Tecnico, Soc. Ferrania. **Mail:** Via Crispi 10, Rome, Italy. **(A, 1948)**

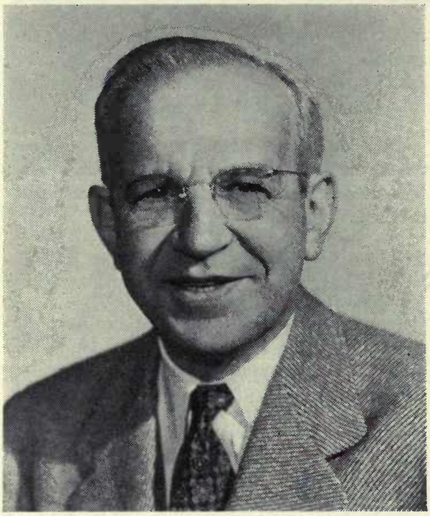
Portalupi, Piero, Director of Photography in Motion Picture Production, Lux Film. **Mail:** Viale Bruno Buozzi 83 int F, Rome, Italy. **(M, 1952)**

Robecchi, Franco, Sound Engineer, Titanus. **Mail:** Piazzale Metronio 1, Rome, Italy. **(A, 1948)**

Trentino, Victor, Motion Picture Sound Engineer, 2 Via Ipponi, Rome, Italy. **(A, 1945)**

Zambuto, Mauro, Technical Director, Scalera Films. **Mail:** Italian Films Export, 1501 Broadway, New York 36, N.Y. **(M, 1952)**

Obituary



Nathan Levinson died on October 18 at his home in Hollywood. He was 64. He was head of Warner Brothers sound department and well known for his work in the early days of sound motion pictures. He was credited, with the late Samuel L. Warner, with responsibility for the first sound film projection which was the musical score for *Don Juan* exhibited in New York in August 1926. Voice reproduction followed in 1927 with the release by Warner Brothers' Vitaphone Corp. of Al Jolson's *The Jazz Singer*.

Born in New York City he was early at work as a Western Union messenger. After learning telegraphy "on his own," Nathan Levinson became a civilian radio engineer with Marconi and for the Navy. World War I found him a Signal Corps Major in command of the Fort Monmouth, N.J., Laboratories. In the early twenties he was a commercial engineer in the radio broadcast field for the Western Electric Co. on the Pacific Coast and in 1925 he was managing director of San Francisco's radio station KPO. A year later he was Warner Brothers' sound director and western division manager of Vitaphone Corp.

Col. Levinson was a Fellow of this Society and most recently served as a member of the Theater Television Committee. He was awarded the Society's Samuel L. Warner Memorial Medal in 1948 "for his outstanding work in the field of motion picture sound recording, the intercutting of variable-area and variable-density sound tracks, the commercial use of control track for extending volume range, and the use of the first sound-proof camera blimps."

He was interested and instrumental in a variety of developments. For instance, the use of 16mm motion pictures with high-speed development, while not an original idea with Col. Levinson, was, under his guidance, commercialized for recording race-track events. During World War II the Navy asked Warner Brothers to take over the manufacture of a special combat camera and responsibility for it was added to Col. Levinson's direction of Warner Brothers' sound department. He was a Warner Brothers' representative on the Research Council for the past twenty years. In 1941, Col. Levinson was given a special award by the Academy of Motion Picture Arts and Sciences for "outstanding service to the industry and to the Army." The next year he received the Academy Award for the best sound recording, that of *Yankee Doodle Dandy*.

SMPTE Lapel Pins

The Society will have available for mailing after September 15, 1952, its gold and blue enamel lapel pin, with a screw back. The pin is a ½-in. reproduction of the Society symbol — the film, sprocket and television tube — which appears on the *Journal* cover.

The price of the pin is $4.00, including Federal Tax; in New York City, add 3% sales tax.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 MEMBERSHIP DIRECTORY.

Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

Appleby, Fredericka, New York University. **Mail:** 810 Broadway, Newark, N.J. (S)

Bell, Charles L., Supervisor of Production (East Coast), The Jam Handy Organization, 1775 Broadway, Rm. 407, New York 19, N.Y. (A)

Birdno, George M., TV Engineer, National Broadcasting Co. **Mail:** 11028 Moorpark St., North Hollywood, Calif. (A)

Bowman, Lester H., Director of Technical Operations, CBS-KNX-KNXT, Columbia Broadcasting System, Inc., 6121 Sunset Blvd., Hollywood 28, Calif. (M)

Brooke, Ned R., Film Director, WSAZ-TV, West Virginia Bldg., Huntington, W. Va. (A)

Brunswick, Lawrence F., Optical Engineer, Colorvision, Inc. **Mail:** 11190 Valley Spring Pl., North Hollywood, Calif. (M)

Burton, John W., Motion Picture Photographer, Engineer, U.S. Navy, 11th Division, Naval Air Station, Anacostia 20, D.C. (A)

Butler, Elliott H., City College, Film Inst. **Mail:** 470 Audubon Ave., New York 33, N.Y. (S)

Cannella, Ben R., Cameraman, Picture House, Inc. **Mail:** c/o Reta Jensen, Mountain, Wis. (A)

Challacombe, Jack A., Foreman, Sensitometric Control Dept., Cinecolor Corp., 2800 W. Olive, Burbank, Calif. (A)

Chullasapya, Brig. Gen. Dawee, Royal Thai Air Force, Bangkok, Thailand. (M)

Cochran, Lee W., Director, Bureau of Audio-Visual Instruction, State University of Iowa, Iowa City, Iowa. (M)

Connor, Roland E., Equipment Engineer, Eastman Kodak Co. **Mail:** 16 Lilac Dr., Rochester, N.Y. (M)

Cotlov, Nelson, Projectionist, South City Drive-In; Film Editor, Capital Film Exchange. **Mail:** 819 Parmley Ave., Yeadon, Pa. (A)

Craig, Stephen R., Motion Picture Sound Engineer, Great Commission Films, Inc. **Mail:** 3455 Meier St., Venice, Calif. (A)

de Forest, Allan F., Manager, Special Services, Peerless Film Processing Corp. **Mail:** 11 Bank St., New York, N.Y. (A)

Embree, Lee R., Motion Picture Photographer, U.S. Air Force. **Mail:** 265 E. Montecito Ave., Sierra Madre, Calif. (A)

Fernandez, R., Carlos, Sound and Theater Engineer, J. Glottmann S.A. **Mail:** Carrera 19, #47–23, Bogota, Colombia. (M)

Foy, Walter L., Chemist, E. I. du Pont de Nemours & Co. **Mail:** 78 Van Liew Ave., Milltown, N.J. (M)

Grunwald, Robert, President, Harwald Co., Inc., 1261 Chicago Ave., Evanston, Ill. (A)

Hann, William G., Film Technician, Cinecolor Corp. **Mail:** 11626 Chandler Blvd., North Hollywood, Calif. (A)

Harris, Franklin S., Jr., Physicist, Department of Physics, University of Utah, Salt Lake City 1, Utah. (M)

Hauser, Willard H., Chief Engineer, WBL-TV, Westinghouse Radio Stations, Inc., 1170 Soldiers Field Rd., Lexington, Mass. (M)

Howell, Joseph E., Chief Engineer, WDSC. **Mail:** 604 Carthage Rd., Lumberton, N.C. (A)

Hubbard, Ray A., Art Director, KPIX. **Mail:** 74 Alta Vista, Mill Valley, Calif. (M)

Izquierdo, Mike, Sound Engineer, Cines Alcazar S.A. (International Amusement Co.). **Mail:** 7539 Taxco Rd., El Paso, Tex. (A)

Jackson, Robert M., Animation Photographer, The Calvin Co. **Mail:** 4117 Mercier St., Kansas City 2, Mo. (A)

Jackson, William J., Chief Engineer, KEYL, San Antonio Television Co., Transit Tower, San Antonio, Tex. (M)

Jewell, James, Television Engineer, Motion Picture Cameraman, WWJ-TV. **Mail:** 26191 Allen Rd., Trenton, Mich. (M)

Jost, Hans Joachim, Albrechtstrasse, 78, Berlin-Steglitz, Germany. (M)

Kaak, Henry W., Jr., Assistant Technical Adviser, Camera Dept., Technicolor Motion Picture Corp. **Mail:** 7745 Agnes Ave., North Hollywood, Calif. (A)

Kelly, Michael, Motion Picture Cameraman, Northrop Aircraft Co. **Mail:** 6109¼ Victoria Ave., Los Angeles 43, Calif. (M)

Klein, Max R., Director, Army Film Library Services, U.S. Army (Civ. Service). **Mail:** 1387 Linden Ave., Highland Park, Ill. (M)

Kraus, Robert W., Apprentice, Motion Picture Laboratory Technician, Precision Film Laboratories. **Mail:** 2006 Benson Ave., Brooklyn, 14, N.Y. (A)

Kuriyama, Tetsuzo, Managing Director, Nippon Onkyo Seiki Co. (Japan Sound Equipment). **Mail:** c/o R. A. Haines, FEC Motion Picture Div., Special Services Section, GHQ, Far East Command, APO 500, c/o P.M., San Francisco, Calif. (A)

Laeser, Phillip B., Television and Radio Engineer, The Journal Co., WTMJ-TV, 720 E. Capitol Dr., Milwaukee, Wis. (M)

Lapins, Theodore, Engineer, H. de Lanauze Cinema Distribution & Service. **Mail:** Isle Perrot, Terrace, Quebec, Canada. (A)

Lewis, Earl W., Radio-Television Engineer, WTVJ. **Mail:** 795 Harbor Dr., Key Biscayne, Miami 49, Fla. (M)

Lewis, J. Kenneth, Recording Engineer, U.S. Navy Dept., Bureau of Ships. **Mail:** 9209 48 Ave., College Park, Md. (A)

Lorenc, Richard M., Electronics Text Development Draftsman, De Forest's Training, Inc. **Mail:** 6925 W. Highland Ave., Chicago 31, Ill. (A)

Lotz, H. Walter, Factory Superintendent, Motiograph, Inc., 4431 W. Lake St., Chicago 24, Ill. (M)

Love, Nathan, Superintendent Technician, Federal Engineering Co. **Mail:** 376 E. Eighth St., Brooklyn 18, N.Y. (A)

Mejid, Kerim, Motion Picture Cameraman, Ministry of Education (Iraq). **Mail:** Audio-Visual Center, 121 College Pl., Syracuse, N.Y. (A)

Metzger, William H., Motion Picture Technician, Ansco, Div. Gen'l Aniline & Film Corp., 405 Lexington Ave., New York, N.Y. (A)

Obata, Toshikazu, Director, Dentsu Motion Picture Co. **Mail:** 104 Mukoyama-Cho, Nerima-Ku, Tokyo, Japan. (A)

Oliver, Francis A., Sound Engineer, American Broadcasting Co. **Mail:** 129 S. Manhattan Pl., Los Angeles 4, Calif. (M)

Palenzuela, Carlos V., Sound Engineer, Westrex Corp. (Asia). **Mail:** 418 Sta. Mesa St., Manila, Philippines. (A)

Petersen, Ernest L., Engineering Coordinator, Electronics Lab., Northrop Aircraft, Inc. **Mail:** 5205 Calderwood St., Long Beach 4, Calif. (A)

Ramos, Augusto B., Technical Department Manager, Philips Portuguesa S.A.R.L. **Mail:** Rua do Telhal, 71-1°-E., Lisbon, Portugal. (A)

Ratcher, Mohammed E., 111 E. 26 St., New York 10, N.Y. (A)

Roberts, Warren S., High-Speed Motion Picture Photographer, Sandia Corp. **Mail:** 2442 La Vetz Dr., N.E., Albuquerque, N.M. (A)

Schock, William R., Television Engineer, KEYL, San Antonio Television Co. **Mail:** 302 Freiling Dr., San Antonio 1A, Tex. (A)

Schuller, Edgar A., Motion Picture Sound Recording, U.S. Army Signal Corps. **Mail:** 30-32 — 50 St., Woodside, L.I., N.Y. (A)

Schutz, George, Editor, Quigley Publishing Co., RKO Bldg., Rockefeller Center, New York 20, N.Y. (M)

Selzer, Robert H., University of California at Los Angeles. **Mail:** 112 N. Highland Ave., Los Angeles 36, Calif. (S)

Sessions, Stanley H., Sound Technician, U.S. Navy Electronics Laboratory. **Mail:** 1886 Malden St., San Diego 9, Calif. (A)

Sombor, Harry, Chief Engineer, Sound Dept., Studio Films, Inc. **Mail:** 1498 Addison Rd., Cleveland, Ohio. (M)

Speed, Richard L., TV Technician, KPIX. **Mail:** 14 Ricardo La., Mill Valley, Calif. (A)

Stainton, Walter H., Cornell University, Goldwin Smith Hall, Ithaca, N.Y. (A)

Stevenson, Paul J., 2231 N. 12 St., Phoenix, Ariz. (S)

Swanell, Lt. Edward F., Motion Picture Officer, Film Editor, U.S. Air Force, 1st Photographic Sqdn., AP&CS, 200 King St., Alexandria, Va. (M)

Vittum, Paul W., Chemist, Research Supervisor, Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y. (M)

Warndorf, Lt. Col. J. P., Chief, Tech. Photo Service Br., Support Div., Wright Air Development Center. **Mail:** 3817 Merrimac Ave., Dayton 5, Ohio. (M)

Watkins, James E., Engineer, Philips Laboratories, Inc., 100 E. 42 St., New York 17, N.Y. (M)

Yoshisaka, Kiyoji, Managing Director, Tokyo Theatre Supply Co., Ltd. **Mail:** c/o R. A. Haines, FEC Motion Picture Div., Special Services Section, GHQ, Far East Command, APO 500, c/o P.M., San Francisco, Calif. (A)

Youngman, John E., Print Foreman, Telefilms, Inc. **Mail:** 4220 McFarlane Ave., Burbank, Calif. (A)

CHANGES IN GRADE

Arnold, John, (M) to (F)
Blake, E. E., (M) to (F)
Cooke, Norman C., (S) to (A)
Dupy, Olin L., (M) to (F)
Freund, Karl, (M) to (F)
Gregory, John R., (S) to (A)
Gretener, Edgar, (M) to (F)
Hanson, W. T., Jr., (M) to (F)
Heppberger, C. E., (M) to (F)
Hood, Henry J., (M) to (F)
Ireland, R. Paul, (A) to (M)
Jensen, A. G., (M) to (F)
Landsberg, Klaus, (M) to (F)
Lawrence, C. Richmond, (S) to (A)
Perkins, Carleton S., (A) to (M)
Reichard, E. H., (M) to (F)
Robertson, A. C., (M) to (F)
Schlanger, Ben, (M) to (F)
Stott, John G., (M) to (F)
Templin, E. W., (M) to (F)
Thulin, Einar, Jr., (S) to (A)

Position Wanted

TV Producer-Director: Now Chief of Production in Army's first mobile TV system; military experience in writing-directing high-speed, low-cost instructional productions; formerly TV producer-director, KRON-TV San Francisco, five shows weekly; will be separated from service Nov. 1952; desire connection in educational TV, preferably employing kinescope techniques; married; prefer West Coast, but willing to travel; résumé, script samples, pictures of work — on request; 1st Lt. Robert Lownsbery, SigC Mbl TV Sys, c/o Sig Photo Center, 35-11 35th Ave., Long Island City 1, N.Y.

Journals Available and Wanted

Available

Upon a reasonable offer to Alfred S. Norbury, 3526 Harrison St., Kansas City 3, Mo.:

Vol. 44 (Jan.-June 1945)	Vol. 50 (Jan.-June 1948)
Vol. 45 (July-Dec. 1945)	Vol. 51 (July-Dec. 1948)
Vol. 47 (July-Dec. 1946)	Vol. 52 (Jan.-June 1949)
Vol. 48 (Jan.-June 1947)	Vol. 56 (Jan.-June 1951)
Vol. 49 (July-Dec. 1947)	Vol. 57 (July-Dec. 1951)

A set of Journals from January 1945 through 1951 at $15.00 plus packing and carrying costs from Richard W. Maedler, 32–52 — 46 St., Long Island City 3, N.Y.

Complete set, in excellent condition, from January 1930 to date, plus one issue of September 1928 from Don Canady, 5125 Myerdale Drive, R.R. 15, Cincinnati 36, Ohio.

5 years (1947–51) in perfect condition plus the indexes for 1936–45 and 1946–50 and including the 1949 High-Speed Photography, upon any reasonable offer to Vic Gretzinger, 3547 Suter St., Oakland 19, Calif.

Transactions Nos. 11, 14, 20, 21, 23, 25, 27, 28 and 38; and 22 years of the *Journal* (1930–1951) except for Jan., Feb., Mar. and Apr. of 1934, Jan. and Apr. of 1948, and Feb. 1950; also these extra single copies — Nov. 1930; Jan., Feb., July and Nov. 1931; June 1932; Mar. and Apr. 1933; Dec. 1934; Jan. and May 1935; Oct. 1938; July and Dec. 1940; Oct. 1948 and Jan. 1950, upon any reasonable offer made to Paul J. Larsen, Assistant to the President, Borg-Warner Corp., 310 So. Michigan Ave., Chicago 4, Ill.

Wanted

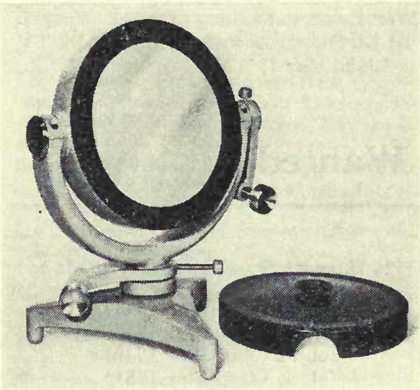
Transactions 1, 6 and 7. Contact Mrs. Dorothy Gelatt, Henry M. Lester, 101 Park Ave., New York 17, N.Y.

High-Speed Photography, Volume 1, reprint or original Journal, March 1949, Part II, by John H. Waddell, Wollensak Optical Co., 850 Hudson Ave., Rochester 21, N.Y.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal*.

New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



Aluminized mirrors specifically designed for Schlieren observation and photography are now available from J. A. Maurer, Inc., Photographic Instrumentation Div., 37–01 31st St., Long Island City 1, N.Y. The Schlieren technique is being widely applied to such studies as air and gas flow, aerodynamics, ballistics, and combustion, permitting visualization and qualitative and quantitative analysis. These mirrors, manufactured by Optical Works Limited of London, England, are available in a number of standard sizes from 4 in. to 18 in. in diameter. Both spherical and plane mirrors are included in this series, with the spherical mirrors available in various focal lengths. These mirrors are manufactured to the highest practical optical precision and are mounted in precise mechanical mounts, permitting coarse and fine adjustment about the vertical and horizontal axes. Detachable metal covers are provided to protect the mirrors when not in use.

Meetings

American Institute of Electrical Engineers (Symposium on The Science of Music and Its Reproduction — 1st Lecture), Nov. 7, Engineering Societies Bldg., New York, N.Y.

Acoustical Society of America, Nov. 13–15, Balboa Park, San Diego, Calif.

American Standards Association, Annual Meeting, Nov. 19, Waldorf-Astoria, New York, N.Y.

Society of Motion Picture and Television Engineers, Central Section Meeting (in conjunction with I.R.E.), Nov. 21, Western Society of Engineers, Chicago, Ill.

American Physical Society, Nov. 28–29, Washington University, St. Louis, Mo.

Society of Motion Picture and Television Engineers, Central Section Meeting (in conjunction with Society of Photographic Engineers), Dec. 3, Bell & Howell Co., Chicago, Ill.

American Institute of Chemical Engineers, Annual Meeting, Dec. 7–10, Cleveland, Ohio

American Institute of Electrical Engineers (Symposium on The Science of Music and Its Reproduction — 2d Lecture), Dec. 11, Engineering Societies Bldg., New York, N.Y.

American Institute of Electrical Engineers (Symposium on the Science of Music and Its Reproduction — 3d Lecture), Jan. 15, Engineering Societies Bldg., New York, N.Y.

Institute of Radio Engineers Conference and Electronics Show, 5th Annual Southwestern Conference and Show, Feb. 5–7, San Antonio, Texas

American Institute of Electrical Engineers (Symposium on the Science of Music and Its Reproduction — 4th Lecture), Feb. 20, Engineering Societies Bldg., New York, N.Y.

The Economics of High-Speed Photography

By A. C. KELLER

The economics of the use of high-speed photography in research and development work are discussed. High-speed photography is a relatively new tool for engineers which can be used to measure mechanical or electrical effects or both at the same time. Examples are given which illustrate the savings in engineering manpower as well as in materials, devices and systems.

It is a pleasure to accept the invitation of your Chairman to discuss some economic aspects of high-speed photography. Bell Telephone Laboratories, of which I am a member, is, as you know, a research and development organization and, for this reason, I will cover the uses and the value of high-speed photography in this area and will take my illustrations from the communications field.

In addressing your Society, of which I have been a member for many years, I would first like to have you observe that it is a society of engineers. I would next like you to remember what the characteristics of an engineer are, particularly in contrast to those of the scientist, physicist, mathematician, etc. As you know, the engineer is indeed interested, and must be trained and informed in, scientific matters *but* he has an additional responsibility which is in his thoughts and actions at all times. This added characteristic of the engineer is his constant concern with the economic value of his activities. He always wants to know, and must know, whether his projects are sound economically.

In order for the engineer to determine the economic value of his work, he must have suitable "tools." The tools which an engineer uses are of many different kinds but none are more important than those which are used for measurement purposes. He must be able to measure many different things in many different ways in order to determine the relative economics of competing solutions of his problems.

Almost sixty years ago, Lord Kelvin discussed the importance of measurements as follows: "When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot

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Presented on October 8, 1952, as the keynote speech for the International Symposium on High-Speed Photography, at the Society's Convention at Washington, D.C., by A. C. Keller, Bell Telephone Laboratories, Inc., 463 West St., New York 14, N.Y.

measure it, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be." This observation is probably more important today than it was sixty years ago, because our apparatus and systems have become more and more complex and operate faster and faster.

One of the most important of our relatively new measuring tools is high-speed photography. The use of high-speed photography in research and development work leading to new devices and new systems and in understanding older devices, is becoming increasingly important. In our own organization we have established a regular service for the use of engineers, which is readily available, in the form of a variety of good equipment and skilled people to operate the equipment.

As measurements are taken of apparatus or systems we frequently change our ideas of how and why devices act as they do. I can think of no other tool available to the engineer which has caused him to change his view of things as much as high-speed photography. Intuition is a valuable human trait but it may easily lead us astray in engineering matters. It has been said that our troubles are not always due to facts we do not know but frequently to those things that we are sure are true but which are in reality untrue. This applies particularly to those things which operate so fast that they cannot be seen or judged by the naked eye. High-speed photography extends our limited human powers of observation. It not only expands time so that we can readily see what happens in extremely short periods of time but it also makes possible the quantitative measurement of these effects.

High-speed photography itself is a broad field of activity and has been covered in many excellent papers which have appeared in the *Journal* of this Society. However, for the application to research and development work, it is important to know that high-speed photography is capable of expanding time for mechanical or electrical effects, or for both at the same time. It can be used to study fast complex mechanical motions and it can also be used to study cathode-ray oscilloscope traces of high speed. The ability to do these things quantitatively has an important economic value.

The economic value of the use of high-speed photography comes about in two major ways:

1. As a saving in manhours of engineering effort by doing a job with fewer men, or—more likely—by doing more jobs with the same men; and
2. As savings in materials, devices or systems either by avoiding failures in service, by extending the useful life of these items or by making faster operation possible so that less equipment may be used to perform the required operations.

To illustrate these savings, some specific examples can be cited taken from the experiences at Bell Telephone Laboratories in research and development activities.

A good illustration of the savings in engineering manpower is the case of the development engineer working on a new and complex mechanism. Without high-speed photography, it might be necessary to build a series of mechanisms and to test all of them for performance and life, a very expensive proposition both in material and in engineering manhours. From the experience gained with such a large variety of designs, it would then be possible to select one particular design for application. In contrast, the more modern practice of using high-speed photography enables the engineer, sometimes from a single model or parts of a model, to determine by measurement whether

there are serious shortcomings in the newly designed mechanism and what the nature of the difficulties is. In this way modifications can be made to solve problems that may not even be known to exist without the help of high-speed photography. These methods have been used with outstanding success in many of our research and development projects, particularly those associated with the complex electromechanical mechanisms which are used in telephone central office apparatus.

A good example of the savings in materials, devices or systems which result from the use of high-speed photography is one that is present in many mechanisms, namely, that of cam actuation where continuous contact between the cam and its follower must be had for quiet operation, longest life and highest operating speed. Another good example is the telephone relay used in switching systems. Each of these relays has an armature operated by an electromagnet. A common problem with relays is that of armature rebound when a relay is released. The armature may bounce one or more times and set up other undesirable vibrations in the structure. In order to avoid false contact operation, it is necessary to wait until the effects are over before again allowing the associated circuits to use the relay. By the use of high-speed photography, it has been possible to redesign relay structures to minimize these vibratory effects and the time for them to be reduced to a neglibible value. Accordingly, the relay can be used by its associated circuit more frequently in a given length of time. In many cases this results in fewer relays in a system to provide necessary operating functions.

From these illustrations it can be said that high-speed photography has made it possible to produce economies in materials, devices or systems by:

1. Extending the life, with corresponding savings in the cost and the materials of replacement units, and
2. Using fewer units to perform the needed functions because higher operating speeds are possible without undue wear.

In order to illustrate the variety of uses of high-speed photography in the research and development area of the communications field, a short motion picture has been prepared. The film has been assembled to indicate the wide variety of uses of high-speed photography in our work. After the showing of the film, I will attempt to summarize the overall economic value of high-speed photography in the work at Bell Telephone Laboratories.

(Examples were shown in a motion picture as follows:

1. stepping switch for dial systems,
2. new wire spring relay for dial systems,
3. crossbar switch for dial systems,
4. mercury contact switch,
5. automatic trouble recorder,
6. cam action in automatic message accounting equipment, and
7. pushbutton telephone set.)

Let us examine the economic value of some of the uses of high-speed photography in the telephone apparatus field. As you know, the Bell System designs, manufactures and uses telephone apparatus and equipment in large quantities to provide much of the nation with telephone service. For example, one of the scenes in the motion picture film showed a study of the step-by-step switch used widely in certain types of central office dial systems. These switches follow the dial pulses and perform other essential operations in establishing a connection between telephone subscribers. Last year the Bell System manufactured more than 600,000 switches of this type. It is obvious that savings of even a small amount on each of this large number of switches would result in a substantial sum of money. In the same way, general purpose relays are used widely in telephone switching systems, and in some of the modern crossbar systems about

five of these are used for each telephone subscriber, so that the total number produced each year is of the order of five million units. Here again, small savings, either in the cost of the relay, its maintenance or in a reduction of the operating time of the relay, have a high economic value because a large number of them are produced and used each year.

Another view of the value of high-speed photography in Bell System research and development work can be taken from the fact that about 700 to 800 100-ft reels of high-speed motion picture film are taken each year. Most of these are carefully studied, frequently by a group of engineers. From these studies, conclusions are reached which result in new and better understandings of the devices and frequently design changes or new designs are the result. Faster processing service of the film would be helpful in expediting development work.

The exact dollar value of the engineering manhours and materials which have been saved by the use of high-speed photography is difficult to evaluate but it is obviously very large in important research and development activities. On one particular project of a device made in large quantities for telephone use, the project engineer estimated that savings of several hundred thousand dollars a year had resulted. Other projects have saved much less and some have shown even larger savings.

In closing, I would like to say that there are many other economic advantages in the use of high-speed photography in maintenance problems, training problems, etc., which I have not touched upon in outlining the engineering value of this tool in research and development work. Our daily use of high-speed photography, leads us to expect an expanding application of this new and important engineering tool and as a result will make better use of that most precious commodity — engineering manpower.

Transient Pressure Recording with a High-Speed Interferometer Camera

By WILLARD E. BUCK

This paper describes a transient-pressure recording camera with a full scale pressure range (by changing diaphragms) of 3 psi to 50,000 psi, and an accuracy of one-half per cent of full scale for any range. Its stability and hysteresis are such that a single static calibration suffices for years of dynamic measurements, and its frequency response varies from 10,000 cycle/sec to 100,000 cycle/sec, depending on the pressure range of the diaphragm used. The paper includes records of interesting applications.

CONVENTIONAL PRESSURE gauges which have high frequency responses are built as follows: A pressure-sensitive device with the required natural frequency (usually a diaphragm or a form of Bourdon tube which has a minute displacement or rotation proportional to pressure applied) is the heart of the instrument. This small rotation or displacement is converted into an electrical response by an electromechanical transducer of the designer's choice, usually either a variable condenser or variable reluctance device. The small electrical impulse thus obtained is amplified and recorded without losing the characteristics of the original signal.

For frequency responses above about 2000 cycle/sec, the most convenient presentation is on a cathode-ray screen. However, if these fleeting signals are to be studied, they must be recorded on photographic film; and further, if the event lasts longer than a very small fraction of a second a continuous moving film camera is usually required.

It is obvious that recording the movement of a diaphragm directly on the photographic film is highly desirable if the system is sufficiently sensitive and has the required frequency response. Such a system exists in the familiar form of interference fringes which can be recorded directly with a moving film camera.

The unique properties which make this system an ideal amplifier are worth further discussion. The amplification factor, defined as the ratio of distance moved by the center of the diaphragm to the corresponding change in fringe diameter, is 14,620 for a fringe pattern using the 5461 A line of mercury and having a distance between light maxima of 2 mm. The frequency response of such an amplifier is approximately half the frequency of the light used. In this example it would be approximately

Presented on October 10, 1952, at the Society's Convention at Washington, D. C., by Willard E. Buck, University of California Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, N.M.

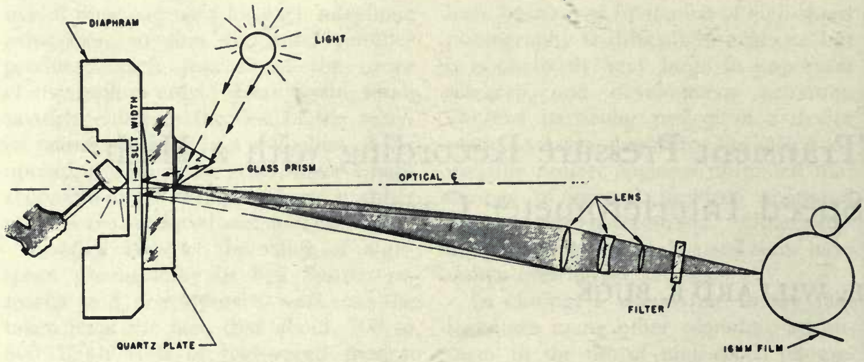


Fig. 1. Schematic of optical system used on interferometer gauge.

2.7×10^{14} cycle/sec. The gain of this amplifier is as constant as the wavelength of light. This, of course, is as good as any quantity we know of and is actually used as the fundamental standard of length measurement.

With such a satisfactory amplifier the characteristics of a pressure measuring device depend entirely on the mechanics of the diaphragm and the recording system used.

A photographic and optical system designed to use such an amplifier was first described in October 1948,[1,2] but is briefly described here again to clarify the remainder of this paper for those who are not familiar with the interferometer gauge.

Optical System

In Fig. 1, a steel diaphragm is receiving a transient pressure as represented by the hammer blow. The diaphragm deflects slightly in response to the pressure, and it is this slight deflection that we wish to record on the moving film. To do this a quartz backing plate, with one face ground and polished spherically concave on a large radius, is placed next to the flat side of the diaphragm. The outer edges of the plate are ground and polished flat to make a highly stable reference with respect to the steel diaphragm.

The spherical cavity in the quartz is coated with a half-reflecting film of aluminum so that when the assembly is viewed in monochromatic light a set of sharply defined interference fringes, or Newton's rings, is formed. If the monochromatic light is admitted through a glass prism as shown in the diagram, however, only a narrow strip of this set of rings is formed. The rings then appear as short sections of arcs and may be photographed on a moving film as distinct parallel lines. Any movement of the diaphragm, however, causes a change in the air space between the quartz plate and the steel, which makes an amplified movement at the sections of arc and a corresponding change in the lines recorded on the moving film.

In practice, the quartz backing piece is ground to produce approximately 50 fringes. Since a deflection of about one-tenth of a fringe can be measured on the film, the displacement of the diaphragm can be measured to about one part in 500.

As long as the deflection of the diaphragm stays well below the elastic limit of the steel or quartz used, it is strictly proportional to the pressure applied. The number of fringes from

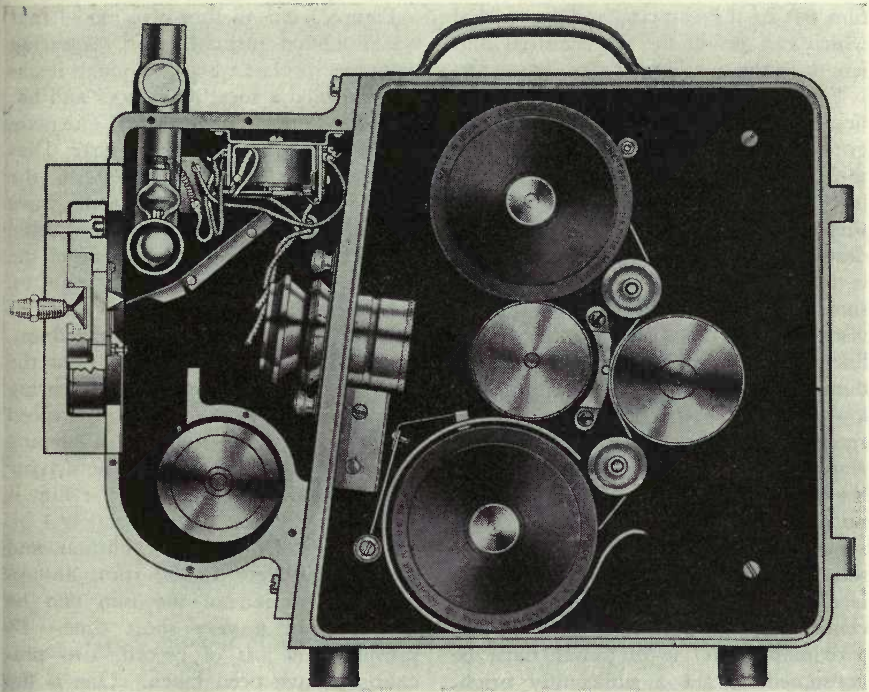


Fig. 2. Cutaway of first self-contained model of interferometer gauge.

the outer ring, which is in contact with the diaphragm, to the center of the diaphragm is directly proportional to the distance from the center of the diaphragm to the quartz backing plate; therefore, the number of fringes counted on a photographic film is directly proportional to the pressure applied. This linear relationship is, of course, a highly desirable feature for ease of calibration and interpretation of records.

Camera Details

The camera proper is of the familiar continuous moving film variety, but the special features of various models which have been developed should be mentioned.

The general scheme for film transport is the same on all models, and consists of a high-speed motor directly coupled to the take-up spool. The speed of the motor is controlled by a governor which is mounted on an idler drum driven by the friction of the film being pulled over it. Thus the motor speed is varied to give a constant film speed as the take-up reel increases in size. On most models the film speed can be controlled from 10 to 80 ft/sec. The supply spool has an adjustable drag to keep tension on the film which supplies driving power for the governor and to keep the film in the image plane. One model which was intended for short runs has a magnetic fluid brake[3] on the take-up reel which is supplied with power as soon as the driving motor circuit is broken. This camera will make as many as ten runs on a 100-ft spool of film at 80 ft/sec, and have the major part of each run at full speed.

One model is equipped with a footage counter which reveals the amount of

film left in the camera, and has a dial which can be set for the required film length in the next run.

Figure 2 is a cutaway drawing of the first self-contained interferometer gauge ever built. It was designed to measure the internal pressure of rocket motors in the range of 0 to 2000 psi. To keep the hot gases of the rocket motor from destroying the diaphragm, the pressure is conducted to the diaphragm by a short oil line. By choosing the proper viscosity of oil and the proper size of line, the diaphragm can be critically damped. The oil line then acts as a low-pass filter so that the frequency response of the system is the frequency response of the oil line itself. By keeping the line short and making sure there is no air in the system, the frequency response can be held above 10,000 cycle/sec. In the lower left corner of Fig. 2 is a blower fan used to keep the light cool. This is necessary because approximately 100 w of power must be consumed to get a sufficiently bright source. Between the two film spools is a slotted disc which is driven by a synchronous motor and puts timing marks on the edge of the film by interrupting the main light beam. The slots in this drum are of varying depths giving 5, 10 and 20 millisecond marks with increased lengths of line in each case to assist in analyzing the film.

In the center of the camera and next to the film frame is a holder for a small cylindrical lens. This lens is not shown in the optical diagram (Fig. 1) as it is not an essential component, but it does serve to reduce the size of the image of the slot on the film, thus increasing the frequency response that can be read for any given film speed. Mounted with its roller on the take-up spool is a microswitch which is operated by the increasing diameter of the take-up spool. This switch interrupts the current to the drive motor and applies energy to the brake on the supply spool.

Figure 3 is a picture of a model that was intended primarily for measuring pressures in blast waves, although it has proven to be a versatile camera and has been put to many other uses. The plate marked "Mounting for Quartz Diaphragm" is mounted flush with the surface over which the shock wave travels. This may be either the inside of the shock tube or the surface of the ground, as the experiment requires. The main features of this design are its ease of construction and its ruggedness. It is, of course, designed to stand the jars that it will receive when measuring shock waves. As in all very high speed cameras, there is a problem in keeping the end of the film intact as the driving motor comes to a stop. If the film is allowed to run free, approximately 1 in. is snapped off on every revolution, and at approximately 10,000 rpm, an appreciable section of the film can be destroyed in a very short time. To prevent this loss of record, two precautions have been taken. One is the microswitch which cuts off the power when the reel gets full, and the second is the two spring leaves which can be seen on either side of the take-up spool. These leaves are mounted so that, as the spool gets full, the film bears against the springs and acts as a brake to bring the motor to a stop in a very short time. With these two precautionary measures in operation the film can be used to within a few feet of the end of the spool without fear of losing a record.

Figure 4 shows the latest 16mm camera design. It is intended to measure pressures in free air or anywhere else that a small size is important. The camera model shown in Figs. 2 and 3 has self-contained power supplies and needs only to be supplied with 110 v a-c and a starting signal. However, this latest camera requires an external power supply as well as a starting signal. As can be seen from the picture, the case is extremely rugged and will stand pressures of 100-lb shock without being

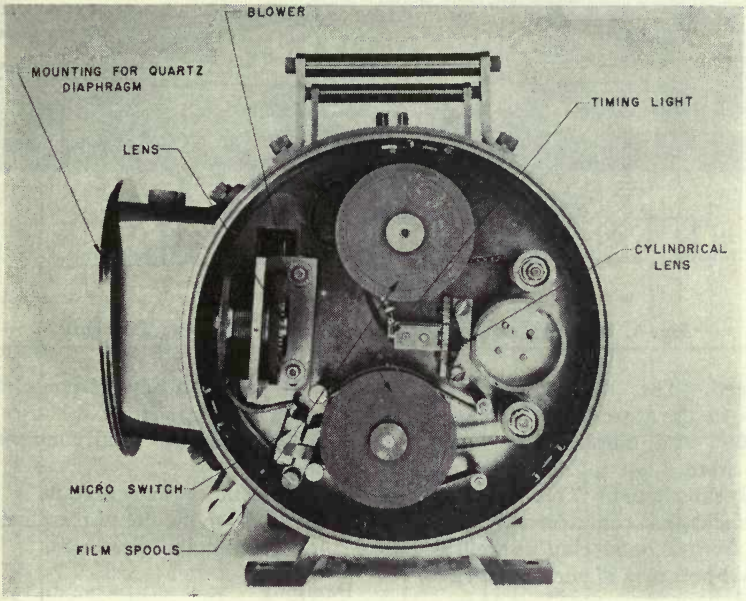


Fig. 3. Interior of model designed for blast-pressure measurements.

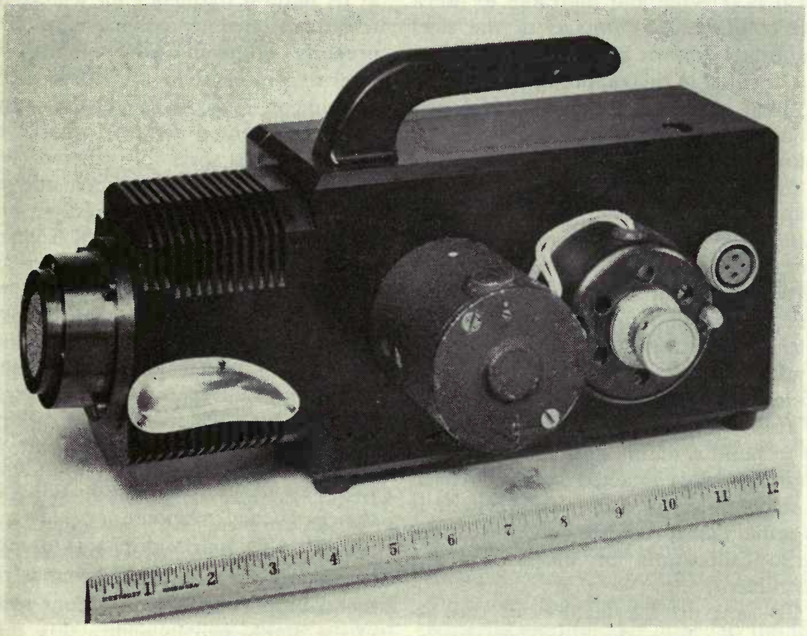


Fig. 4. Compact 16mm interferometer gauge.

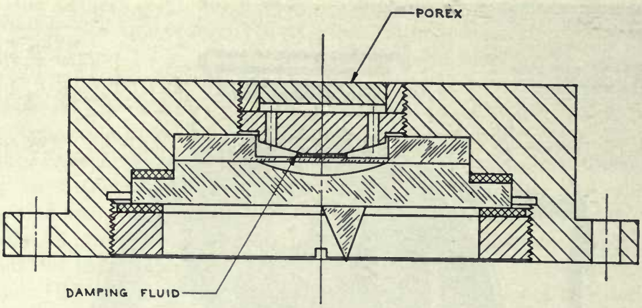


Fig. 5. Drawing of quartz diaphragm and damping assembly.

damaged. The diaphragm assembly shown in the extreme left is easily detachable, and diaphragms varying in range from 3 psi to 50,000 psi can be quickly substituted. This makes a single instrument that can record the pressure wave from a hand clap as well as the internal pressures of our largest rifles.

Diaphragm Construction

For pressures in the range of 3 to 100 psi it is possible and desirable to use a quartz diaphragm instead of the steel diaphragm shown in Fig. 1. Figure 5 is a drawing of this diaphragm assembly.

Fused quartz is an almost ideal material for a pressure diaphragm. Its ratio of Young's modulus to density is high, thus allowing a high natural frequency for a given pressure range. Fused quartz also has one of the smallest temperature coefficients known, and consequently its calibration is almost independent of temperature. The most interesting feature of the quartz diaphragm, however, is its ability to be optically contacted with another piece of fused quartz. This property allows us to build a diaphragm and a backing plate optically contacted together to form a single integral unit. This system is so stable that it requires only one careful static calibration for the life of the instrument.

To sum up the features of this assembly, we have the following characteristics:

1. High frequency response for a given pressure range.
2. A negligibly small temperature coefficient.
3. A stability that permits a single calibration for the life of the gauge.
4. No detectable hysteresis.

Damping

This quartz diaphragm, with almost perfect elastic properties, will vibrate at its natural frequency for a long time when subjected to a shock wave if not properly damped. One of the most difficult problems in the design of this instrument was to find the proper damping method for the quartz diaphragm. All sorts of schemes were tried, but all systems that gave adequate damping loaded a diaphragm so much that they reduced its natural frequency two or three times. This, of course, was highly undesirable, as one of the main features of the gauge is its high frequency response. Finally, almost by accident, it was found that if the direction of motion of the damping fluid was at right angles to that of the diaphragm, the mass of the damper did not add to the mass of the diaphragm and hence the frequency response was not destroyed. To accomplish this damping it was only necessary to bring a rigid metal support close to the front surface of the diaphragm in such a way that a drop of the proper viscosity fluid could

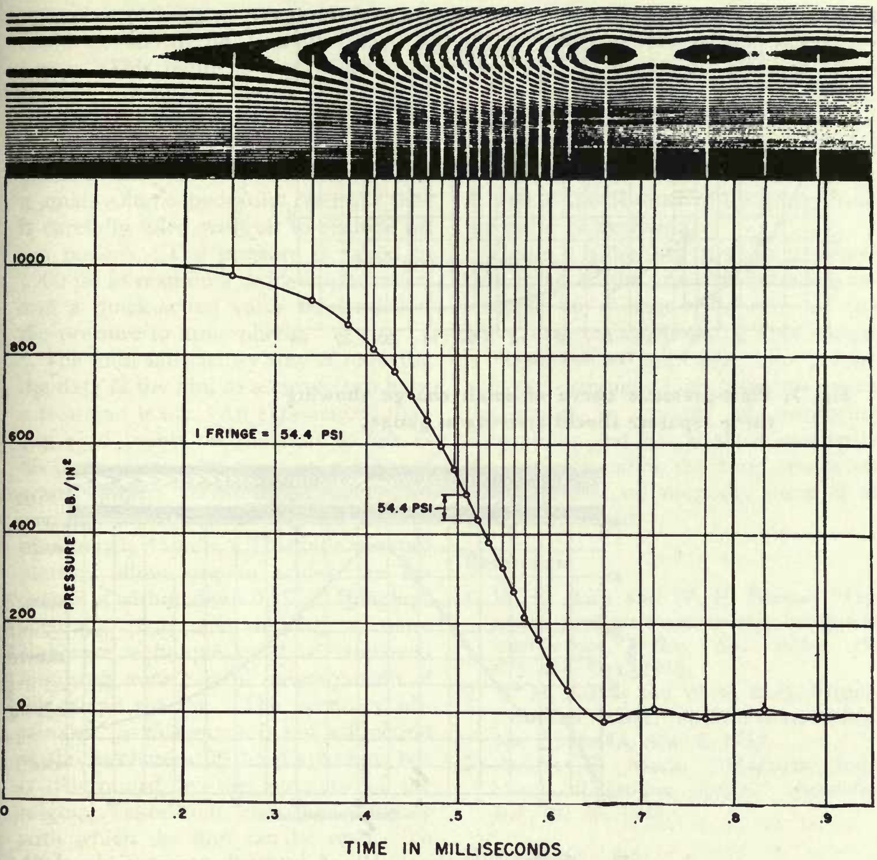


Fig. 6. Enlargement of an original record and method of plotting pressure-time curve.

be placed between the diaphragm and the metal support.

As the diaphragm deflects, the oil must flow along the face of the diaphragm to accommodate the change in volume between the diaphragm and the metal support. Damping is caused by the viscosity of the oil. Decreasing the clearance between the support and the diaphragm will increase the velocity of the oil and hence its damping action. A 0.040-in. diaphragm with a pressure range of 0 to 70 psi is critically damped if a 1000-centistoke oil drop is used with a clearance of about 0.004 in.

Figure 5 also shows the diaphragm damper and filter unit combination. The damping fluid is held in place between the metal plate and the diaphragm by its surface tension. After several months of field use, diaphragms have been inspected, and the oil drops have been found to be intact and damping properly.

As these gauges are intended for field use of the most exacting kind, it was found necessary to put a water and dust filter over the diaphragm proper. The material used for this filter has the trade name "Porex." It is manufactured by

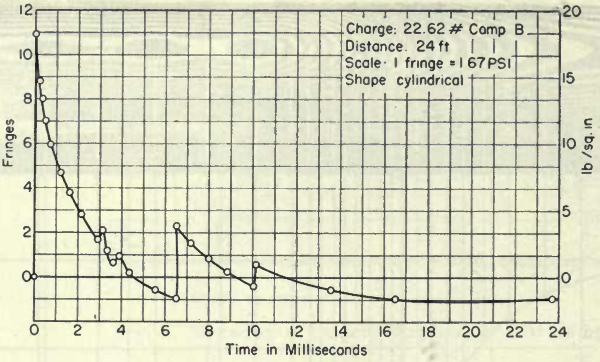


Fig. 7. Blast-pressure curve of small charge showing three separate shocks arriving at gauge.

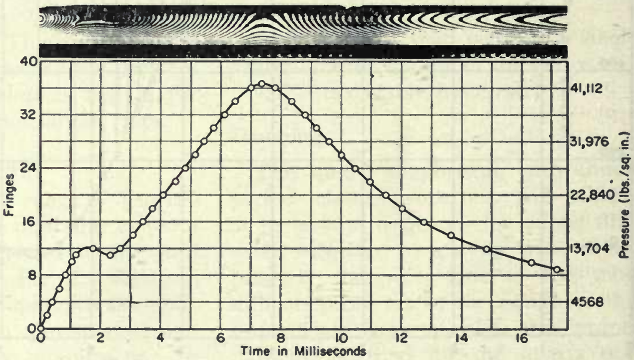


Fig. 8. Pressure-time plot of internal pressure developed by a typical large-caliber rifle.

Moraine Products Division of General Motors Corp. "Porex" is made of a large number of small beads which are bonded on their outer edges by heat and pressure until the whole unit is quite rigid but leaving a fair percentage of air passage between the balls. The "Porex" after manufacture is dipped into hot paraffin and the excess paraffin blown out with compressed air. This leaves each individual ball coated with a very thin layer of paraffin which will not be wet with water droplets. A "Porex" filter thus treated will not pass water even though it is immersed one-quarter inch or so. A blast gauge thus protected can be left out in the dust and rain even though its sensitive diaphragm is turned up flush with the ground. By keeping the volume of air small and the area of the "Porex" disc large, the flow time is so rapid that it does not measurably decrease the frequency response of the diaphragm.

Records

It is difficult to find a practical record that can be displayed on a magazine page, as most events of interest are a number of milliseconds long and would require many feet of paper to present them adequately. The record of Fig. 6

was chosen because the whole event could be shown on a single sheet of paper. This figure not only shows an enlargement of the original record, and the graph of pressure vs. time obtained from it, but also shows the method of plotting this curve. The record is of a small-volume hydraulic reservoir that is carefully filled with oil to exclude all gas pockets. The pressure is raised to 1000 psi as read on a dead-weight tester, and a quick-acting valve then releases the pressure to atmospheric.

The most satisfactory way of reducing the data of the film to a curve is to have a two-man team. An experienced man can read points off the film as fast as his partner can plot them on a piece of graph paper. With this system an average curve can be plotted in approximately 15 min. This type of rapid plotting allows one to achieve an accuracy of within about 0.5%. If higher-accuracy plots are desired, a more elaborate technique must be employed requiring some careful measurements of the fringe spacing. The accuracy obtainable by this gauge is not a function of the mechanics of the diaphragm but is determined by the accuracy of the original calibration and the accuracy with which the film can be read. To date we have never had an application in which the highest possible accuracy was required. We, therefore, have no data on what ultimately might be obtained.

Figure 7 is a blast-pressure curve taken with the gauge shown in Fig. 3. This shot was taken on an asphalt apron that was level and dust-free. The diaphragm of the gauge was mounted flush with the surface of the apron and at a 24-ft air-line distance from the explosive. The explosive was a 22.6-lb cylinder of Composition B suspended in the air by a small string and having its cylindrical axis at right angles to the line of measurement. It was detonated simultaneously in the center of each end of the cylinder. The record shows clearly three separate shocks arriving at the gauge. These shocks are probably due to the interreaction of wave fronts from the cylindrical and flat sections of the charge, respectively. The secondary shock fronts are a function of the orientation of the cylindrical charge as well as the distance of the gauge from the point of explosion.

Figure 8 is the first part of a pressure-time plot of the internal pressure developed by a large rifle such as the Navy uses on shipboard. This record is presented to emphasize two points: one, the extremely high pressures which the gauge is capable of measuring accurately; and two, to show how easily the gauge handles the time resolution of events that we normally think of as being very rapid.

Reference

1. W. E. Buck and W. H. Barkas, "Dynamic pressure measurement by optical interference," *Rev. Sci. Instr.*, *19:* 678–684, Oct. 1948.
2. W. H. Barkas and W. E. Buck, "Interferometer gauge," U.S. Patent Office, No. 2,591,666, Apr. 8, 1952.
3. Robert C. Mack, "Magnetic fluid clutch of unique design," *Automotive Ind.*, *98:* 38, 1948.

Discussion

Morton Sultanoff (*Terminal Ballistics Laboratory*, *Aberdeen Proving Ground*, *Md.*): By the appearance of the gauge, I would assume you are measuring the reaction of gauge material to the shock. How do you correct back to the actual shock from the response of the gauge material?

Dr. Buck: The quartz diaphragm actually responds to the shock profile within the limitations of its frequency response which is 10,000 to 100,000 cycles per second depending upon the pressure range used. The diaphragm does not, however, follow the shock exactly, as the shock pressure rises in much less than one hundred thousandths of a second. A pressure-time curve plotted with points every tenth of a millisecond would not see an error between actual and measured values, but if these points were plotted

at one hundredth of this spacing, a definite discrepancy at the shock front would be evident.

Kurt Stehling (Bell Aircraft): The question I have is your application to rocket motors. Do you use a microdensitometer? If so, you have several miles of film. The second question I have is, did you say the quartz is semialuminized on its surface?

Dr. Buck: Yes. If the quartz is not semialuminized, the fringes are very difficult to photograph, but if it is aluminized to the proper reflectance, the contrast between light and dark fringes is high, so that it is very easy to photograph.

In answer to your first question. I have not had an application where the accuracy required warranted the use of a microdensitometer. Reading quickly by eye an accuracy of 0.5 per cent is easily obtained. By using a microdensitometer the reading accuracy could probably be pushed well beyond this point.

Mr. Stehling: I was not thinking so much of the accuracy as the ability to take this data and feed it to a computer or card system, an IBM system.

Dr. Buck: We have not tried to use a card system as points can be read from the film about as rapidly as they can be copied down. A normal shock wave curve such as shown in this paper takes about 15 minutes to plot.

Amy E. Griffin (U.S. Naval Ordnance Test Station, China Lake, Calif.): I would like to make a comment that there are quite a few machines that have been developed in the last few years for analyzing records of this type, in which you have a motor control to transport film over to a certain position so that the operator can get the image by feeding a film—it can be fed automatically into a computer at the same time for further computations.

Kenneth Morgan (Interchemical Corp.): I do not quite understand how you obtained the original calibration so that you know what distance corresponds to what pressure.

Dr. Buck: We had a great deal of difficulty proving that a static calibration was equivalent to a dynamic one; however, through numerous tests such as comparing a static calibration to the peak pressure in a shock wave as measured by velocity gauges, we have gradually accumulated enough data to convince almost anyone. Once you have established the equivalence of a static and dynamic calibration it is simple to get as accurate a static calibration as required. The pressure element is clamped onto a pressure chamber and subjected to various pressures as measured by a dead weight tester. A short section of film is run for each pressure and a curve of pressure against fringe change plotted.

Optimum Slit Height in Photographic Sound-Track Reproducers

By W. K. GRIMWOOD and J. R. HORAK

For a specified reproducer frequency-response characteristic, there exists an optimum slit height. The optimum slit height depends upon the relative amounts of shot noise from the photosurface and thermal noise from the amplifier circuits. Calculated and measured values of optimum slit height are presented. The slit height which minimizes noise is undesirably large. Shot and thermal noise levels may be ignored if the d-c voltage drop across the effective phototube load resistor, without film in the light path, is of the order of 300 mv or higher.

THE TERM "optimum" when applied to the height of the scanning slit in a photographic sound-track reproducer can be variously interpreted. One interpretation appearing in the literature of the subject is the slit height which gives maximum signal output at an assigned frequency,[1] another is that slit height which results in maximum ratio of signal-to-phototube noise at an assigned frequency.[2] The definition of "optimum" taken as the basis for this paper is that value of slit height which gives maximum signal-to-system noise ratio for a specified frequency-response characteristic as measured from film modulation to amplifier output. Film noise plays no part in the determination of optimum slit height. The effective size of the scanning beam is determined, not by the optical slit image, but by the overall response of the system. Since the reproducer frequency-response characteristic is fixed, the *effective* slit height is fixed. The reasonable assumptions are made that all phototube noise is shot noise and that all amplifier noise is thermal noise arising in the input coupling circuit. Both sources of noise have, therefore, the spectral distribution of "white noise" before any frequency discrimination is encountered.

The reproducer frequency-response on which are based the calculated and experimental data in this paper is one of the Standard Electrical Characteristics for Theater Sound Systems[3] specified by the Motion Picture Research Council (Fig. 1). The same set of curves have been proposed as standards for 16mm review rooms.[4]

Communication No. 1514 from the Kodak Research Laboratories, by W. K. Grimwood and J. R. Horak, Kodak Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y., presented by J. R. Horak on October 10, 1952, at the Society's Convention at Washington, D.C.

Since the Standard Electrical Characteristics do not extend higher than 8000 cycles/sec, this frequency has been taken as the cutoff frequency for convenience in expressing slit height as a ratio to the cutoff wavelength, λ_c. Because the electrical response cannot suddenly cease at 8000 cycles/sec, the equalizer curves of Fig. 2 have been carried beyond this frequency at a rate of loss which appears reasonable and practical. High-frequency discrimination by electro-acoustic and acoustic elements has not been included in the calculations. These factors, when known, can readily be taken into account. Their inclusion will theoretically shift the optimum slit height slightly in the direction of higher slits. Likewise no attempt has been made to include subjective factors which might weight the noise spectrum.

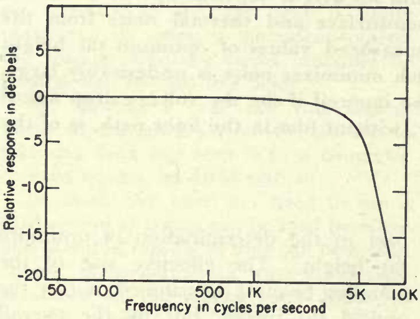
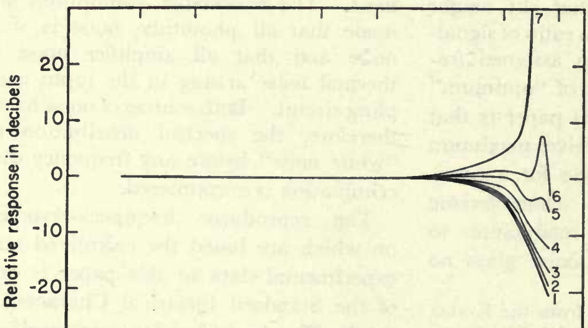


Fig. 1 Standard Electrical Characteristic.

Theoretical Optimum Slit Height

Consider a sound reproducer consisting of an optical system which projects on the film plane a sharply defined, uniformly illuminated scanning beam. The scanning beam impinges upon a film which has constant average transmittance and a percentage modulation which does not vary with wavelength. The light transmitted by the film falls upon a phototube which is coupled to an amplifier. The amplifier is considered to be so designed that constant percentage light modulation produces an output level, the frequency dependence of which is specified by Fig. 1. If the height of the scanning beam, h, is changed, the average light level upon the phototube and the average phototube current will change proportionately. The shot-noise power generated in the phototube is proportional to the phototube current. Thermal-noise power, arising in the coupling circuit, is constant per cycle of bandwidth for a fixed temperature.[5,6] For frequencies



Curve	h/λ_c
1	0.133
2	0.318
3	0.477
4	0.634
5	0.823
6	0.938
7	1.111

h = slit height,
λ_c = wavelength at 8000 cycles/sec.

Fig. 2. Equalization required to match Standard Electrical Characteristic.

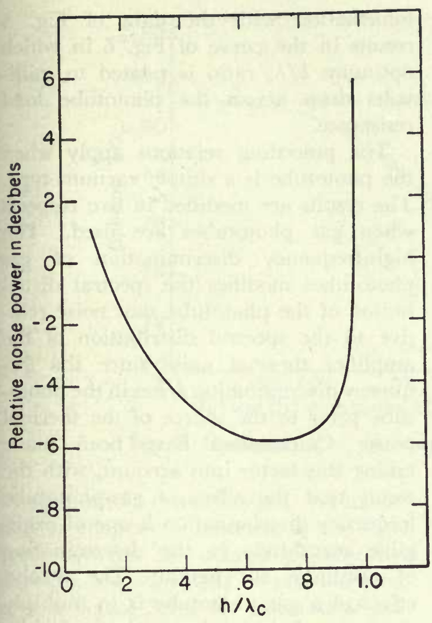


Fig. 3. Shot-noise power vs. h/λ_c.

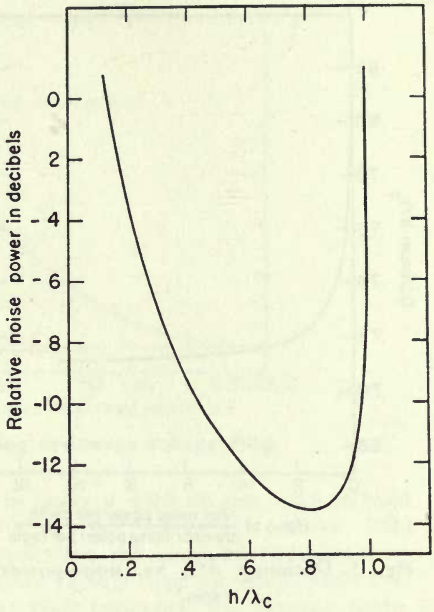


Fig. 4. Thermal-noise power vs. h/λ_c.

where the height of the scanning beam is small compared to the wavelength of the film modulation, the signal amplitude will be proportional to the scanning-beam height. Thus, in this frequency range, the ratio of signal amplitude to shot-noise amplitude will be proportional to the square root of the slit height. The ratio of signal amplitude to thermal noise will be directly proportional to the slit height.

At frequencies where the slit height is an appreciable fraction of the modulation wavelength, the signal amplitude will also be a function of frequency.[7] Since the overall frequency response has been specified, the product of the frequency discrimination due to the slit height and the frequency discrimination due to amplifier compensating equalizers must remain fixed. The necessary amplifier-frequency characteristics, plotted with decibel ordinates, are shown in Fig. 2. These equalizer characteristics distort the frequency spectra of shot and thermal noises. Because of the frequency characteristics of the amplifier equalizers, both noise levels will be functions of slit height. The rms noise voltage must be determined by integration of noise power per cycle over the frequency band of the amplifier. This may be done graphically by plotting the equalizer characteristics as the amplitude squared *versus* the frequency, measuring the areas under these curves and taking the square roots of the areas. Each such calculation gives the noise voltage, either shot or thermal, associated with a particular ratio of slit height to wavelength. Signal-to-noise ratios *versus* slit height-to-wavelength ratio can now be plotted. Figure 3 is a plot of shot noise in decibels *versus* the ratio of slit height to wavelength at cutoff. Figure 4 is a similar curve for thermal noise. In both figures, the noise levels are referred to an arbitrary fixed signal level at the amplifier output.

Minimum noise level occurs at slightly different h/λ_c ratios on the two curves of Figs. 3 and 4. The minimum

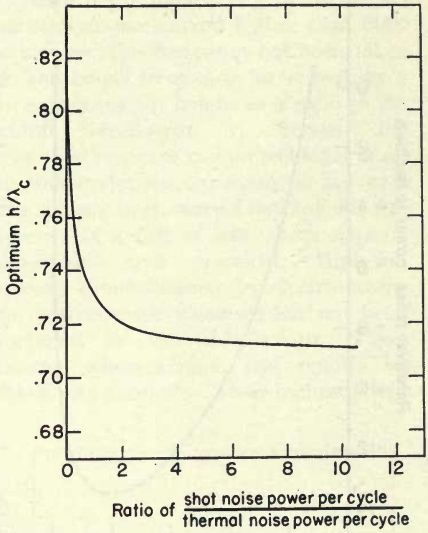


Fig. 5. Optimum h/λ_c vs. noise-power ratio.

total noise must be at an h/λ_c ratio between these two minima. The optimum slit height will thus be a function of the ratio of shot noise to thermal noise. The individual noise components can be added vectorially for various assumed ratios of shot noise to thermal noise, and the total noise plotted against h/λ_c, with noise ratios as a parameter. The locus of the minimum of this family of curves may then be plotted as optimum h/λ_c *versus* the ratio of shot noise to thermal noise, as in Fig. 5.

It has been shown[5,8] that shot noise and thermal noise are equal when the product of the average phototube current by the effective* phototube load resistance is 50 mv. This relation may be used to plot shot noise-to-thermal noise ratio *versus* the average voltage across the phototube load. Combining this information with the data of Fig. 5 results in the curve of Fig. 6 in which optimum h/λ_c ratio is related to millivolts drop across the phototube load resistance.

The preceding relations apply when the phototube is a simple vacuum type. The results are modified in two respects when gas phototubes are used. The high-frequency discrimination of gas phototubes modifies the spectral distribution of the phototube shot noise relative to the spectral distribution of the amplifier thermal noise since the frequency discrimination arises in the phototube prior to the source of the thermal noise. Calculations have been made taking this factor into account, with the result that the effect of gas-phototube frequency discrimination is one of negligible magnitude in the determination of optimum slit height. The second effect of a gas phototube is to multiply the ratio of shot noise to thermal noise by the gas amplification factor. Thus, the millivolt scale of Fig. 6 must be divided by the gas amplification factor when this curve is applied to gas phototubes. This same effect would apply were a photomultiplier tube to be used for sound reproduction. The obvious practical effect of using a photomultiplier tube would be the elimination of thermal noise, so that only the curve of Fig. 3 would be pertinent.

Measured Optimum Slit Height

Measured data were taken using a 16mm sound-film reproducer designed some years ago by J. G. Streiffert, of these Laboratories. This machine is well adapted to measurements with various slit heights by virtue of its double-slit optical system with a series of interchangeable secondary slits. An 8.5-v, 4.0-amp lamp and conventional sound-reproducer optical system are used to form a slit image, approximately 1.2 mils in height, at the film plane. The slit image at the film plane is enlarged 6.5 times by a microscope objective and

* Whereas the d-c voltage is developed across the phototube anode resistor, the noise components appear across the effective a-c load impedance in the anode circuit.

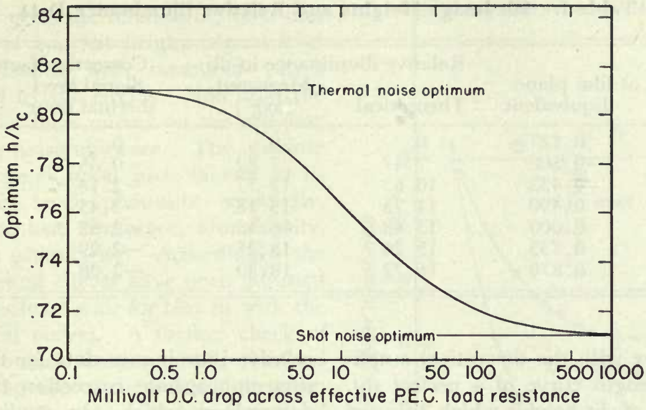


Fig. 6. Optimum h/λ_c vs. coupling resistance voltage drop.

imaged onto a secondary slit. A motor-driven chopper is inserted in the light path between the microscope objective and the secondary slit to provide a reference signal level for calibration purposes. The chopping frequency is approximately 200 cycles/sec. Radiation passed by the second slit is collected by a lens which images the objective lens onto the phototube surface. The phototube is a Type 927 (S-1 surface) operated at 52 v. This subnormal anode voltage is used because frequency discrimination due to the gas-amplification factor was found to be negligible at this voltage level. The phototube load resistor of 2 megohms is also the grid resistor of the amplifier. The amplifier is followed by a series of filters and a vacuum tube voltmeter. For each of the seven available secondary slits, the amplifier was separately equalized by an adjustable equalizer in the feedback path so that the overall response, as measured at the voltmeter position by means of a calibrated frequency test film, approximated the response curve of Fig. 1. The maximum spread between the seven response curves is 0.7 db from 50 to 7000 cycles/sec, increasing to 2.1 db at 8000 cycles/sec. The maximum deviation between the group of seven measured responses and the standard curve of Fig. 1 is within the limits of +0.8 db and −0.4 db from 50 to 7000 cycles/sec. Above 7000 cycles/sec, the measured responses drop more rapidly than the design objective; at 8000 cycles/sec, the extreme deviation is −6.1 db. Above 8000 cycles/sec, the electrical response drops very rapidly so that, in spite of the equalizing required for the largest slit, the noise components above 9000 cycles/sec are negligible. All noise measurements are made with a 500-cycle/sec high-pass filter in order to remove any hum components present. This filter is removed when measuring signal levels. The noise level with the amplifier input shorted is 20 db below the noise level with the normal input condition. This measurement is for a 200-cycle/sec bandwidth centered at 8000 cycles/sec; at lower frequencies, the noise with a shorted input is a few decibels lower.

The theoretical noise *versus* slit height curves are based upon the assumption that the slit is perfect, that is, the boundaries are sharply defined and the illumination is perfectly uniform over the entire image area. Since, in practice, this condition is rarely satisfied, it is necessary to define an "equivalent slit height." Equivalent slit height is that value of slit height determined by matching a measured amplitude-wave-

Table I. Slit Image Heights and Relative Illuminance Data

Slit height at film plane Calculated	Equivalent	Relative illuminance in db Theoretical	Measured (avg.)	Correction factors in db Signal level thermal noise	Shot noise
0.127	0.127	0	0	0	0
0.290	0.300	7.47	7.82	−0.35	−0.18
0.447	0.432	10.63	12.77	−2.14	−1.07
0.605	0.490	11.73	15.18	−3.45	−1.73
0.861	0.600	13.48	16.10	−2.62	−1.31
1.047	0.735	15.26	18.25	−2.99	−1.50
1.180	0.870	16.72	18.80	−2.08	−1.04

length curve with the theoretical amplitude-wavelength curve of a perfect slit. The values of slit heights which are used here in plotting measured noise levels have been determined by this technique. The precision of determining slit height from slit-loss data becomes rather poor for very small slit heights, since it was not practical to make measurements at wavelengths of much less than 1 mil. However, measurements of the light distribution along the height of the image of the primary slit show that the uniformity is very good for the smaller values of secondary slit height when the secondary slits are properly aligned with respect to the primary slit image. At the smaller slit sizes, the equivalent slit height approaches the value determined by dividing the measured height of the physical secondary slit by the magnification. For the smallest value of secondary slit, this calculated value is used since it is corroborated by the equivalent slit-height data.

The theoretical curves are also computed on the assumption that the illuminance upon the phototube is proportional to the slit height. Measurements show that this assumption is not, in this instance, justified. Although the data are consistent within each slit height, there are inconsistencies between the series of data for the several slits due to factors such as the necessary realignment of optics when changing slits, adjustments of lamp position for minimum microphonics, etc. From the relative illuminance data for the several slits, appropriate correction factors are determined which are applied to all signal and noise level data. Table I gives the slit image heights, relative illuminance data, and the correction factors.

For each of the seven slits, a series of measurements were taken of signal levels for both chopped light and calibrated film, film noise level, phototube noise level, and amplifier noise level. Nondiffusing neutral densities placed in the light beam ahead of the phototube were used to control the ratio of phototube noise to amplifier noise. The illuminance at the phototube, with the smallest slit in place and no density or film in the light path, was such that phototube noise was 7 db above thermal noise. Since the total noise level and the thermal noise level were known, the phototube noise level could be calculated. The correction factors of Table I were applied to these data, and all measurements were adjusted to a common signal reference level. The slit sizes are expressed as ratios of slit height to the wavelength corresponding to a cutoff frequency of 8000 cycles/sec.

The results are shown by the curves of Fig. 7. Curve A is the theoretical relation between shot noise and slit height taken from Fig. 3. The crosses are experimental points. Similarly, Curve B is the theoretical thermal noise *versus* slit-height relation of Fig. 4, the squares representing experimental data.

Curve C gives the relation between film noise level and slit height (signal level held constant) with measured values indicated by the circles. Note that the location of these curves on the ordinate scale has no significance. The absolute levels depend upon such factors as illuminance level, phototube sensitivity, phototube load resistance, film density, and film granularity. Accordingly, the experimental curves have been adjusted on the ordinate scale for best fit with the theoretical curves. A further check of the theoretical results may be obtained by making use of the relation between the phototube d-c output voltage and the ratio of shot noise to thermal noise. The measured gas-amplification factor (anode volts = 52) is 2.3, so that unity noise ratio should be obtained when the d-c voltage drop across the phototube effective load is 22.5 mv. The measured value is 23.8 mv.

Discussion of Results

The optimum slit height for minimum electrical noise level is, from Fig. 7, some value of h/λ_c between 0.71 (minimum phototube noise) and 0.81 (minimum amplifier noise). Using the former value gives an electrical noise level not more than 0.4 db higher than the true optimum. An h/λ_c value of 0.71 gives actual slit heights of 0.64 mils and 1.60 mils for sound-reproducer speeds of 7.2 in./sec and 18 in./sec, respectively. The corresponding slit loss at a frequency of 8000 cycles/sec is 8.9 db. A slit loss of this magnitude is undesirable, partly because of the required equalizing, but chiefly because relatively small differences between actual slit heights and design value will cause appreciable changes in overall frequency response. If phototube noise is much greater than amplifier noise, there is considerable tolerance in the choice of slit height. Then h/λ_c may have values from 0.44 (at which value the slit loss is but 3 db) to 0.9 without increasing the noise level by more than 1 db.

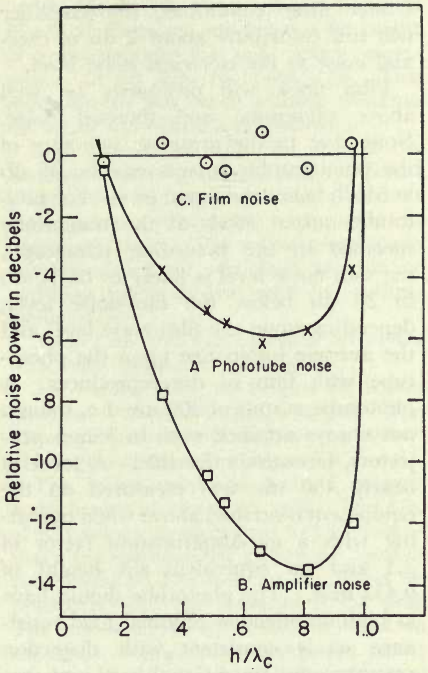


Fig. 7. Relative noise power vs. h/λ_c: ——— = Theoretical curves; ⊙, □, × = Experimental points; Curves adjusted to 0 db at h/λ_c = 0.133.

Because phototube noise voltage is proportional to the square root of illuminance, the most adverse conditions, with respect to the ratio of phototube noise to amplifier noise, exist when noise-reduction sound tracks are used. The illuminance on the phototube during a silent portion of a noise-reduction track may be only about 5% of the illuminance with no film in the reproducer. Assuming the phototube to have a gas-amplification factor of 6 and no film in the light path, the d-c level across the effective phototube load resistor must be about 300 mv (this is equivalent to 106 rms mv for 100% light modulation, as by a sinusoidal light chopper) for phototube-noise power to be double the amplifier-noise power when a fully biased noise-reduction sound track is reproduced.

Under these conditions, the amplifier will still contribute about 2 db of thermal noise to the electrical noise level.

Film noise will ordinarily be well above phototube and thermal noise. Noise due to the granular structure of the photographic image may be 45 db to 55 db below the signal level. For phototube output levels at the magnitude specified in the preceding paragraph, the shot-noise level is likely to be 10 db to 20 db below the film-noise level, depending upon the film-noise level and the average luminance upon the phototube with film in the reproducer. A phototube output of 300 mv d-c, though not always attained even in 35mm projectors, is entirely feasible. A level of nearly 450 mv was measured on the equipment described above when operating with a gas-amplification factor of 2.3 and an equivalent slit height of 0.432 mils. The phototube should have as high an effective physical load resistance as is consistent with distortion requirements, since signal level and shot noise increase more rapidly as a function of the load resistance than does thermal noise.

Conclusion

It has been shown that the slit height giving maximum signal-to-electrical noise ratio in a photographic sound reproducer may be readily calculated. The necessary data are the desired overall frequency-response characteristic, the phototube gas-amplification factor, and the d-c voltage drop across the phototube effective load resistor at the illuminance level for which the noise is to be minimized. The optimum slit height so found is undesirably large. Phototube and amplifier noise levels become relatively unimportant, thus permitting wider choice of slit height, if the phototube d-c output level, assuming a gas-amplification factor of 6, is 300 mv or over, without film in the machine. An output level of this magnitude is readily attainable.

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Discussion

Maxwell A. Kerr (Navy Department, Bureau of Ships): What type of first tube was in your amplifier?

Mr. Horak: I had direct coupling between the phototube and my first amplifier tube and the first amplifier stage was a 12J5 cathode follower to lower the impedance feeding the long cable to the main amplifier.

Mr. Kerr: The reason I ask that is that these conclusions are based on what seems to be a cesium-type phototube. For instance, there are no measurements on the lead sulfide type, are there?

Mr. Horak: I have no measurements on lead sulfide tubes at all.

Mr. Kerr: I see. I just wondered if that wouldn't change the ratios on that curve.

Mr. Horak: If the same Standard Electrical Characteristic is maintained, and if the lead sulfide tube actually has a white

noise spectrum, and the noise varies with the light level in the same manner as shot noise, the curves would be correct. If the noise characteristics are known, the same method of computation can be applied to any type photocell. The character of the noise introduced by the lead sulfide tube may be different from that of shot noise and perhaps the absolute noise level would be greater.

Mr. Kerr: Except that our experience has been that the signal-to-noise ratio was much higher on the lead sulfide tube.*

Mr. Horak: I'm not too familiar with lead sulfide tubes, but I believe the noise level is perhaps a little higher and the signal level is much higher.

Mr. Kerr: That's right.

George Lewin (Signal Corps Photographic Center): Are the optimum values you have arrived at by this investigation radically different from practice in commercial projectors?

Mr. Horak: We measured one Eastman Model 25 Projector and it has a slit height of approximately 0.5 mil, which corresponds to an h/λ_c of about 0.55. This measurement was made without checking the focus and azimuth adjustments.

As I pointed out, the film noise is the dominant factor. If you have sufficient illumination on the phototube, it doesn't really matter, within wide limits, what slit height you have. The determining factors are how much do you want to equalize and how critical do you want your adjustments to be.

Anon: Can you manufacture projectors with these optimum slit heights?

Mr. Horak: These slit heights are within practical manufacturing ranges. The 16mm projectors need to have equivalent slit heights of between 0.64 and 0.73 mil.

The 35mm projectors have, I believe, a slit height of about 1.2 mils. The h/λ_c of 0.71 would be equivalent to 1.64 mils — that's the optimum for phototube noise — that would be 1.64 mils for the 35mm reproducers, and the standard is 1.2 mils. The standard was apparently selected on the basis of practical equalization rather than on the basis of minimum electrical noise level.

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* Lowell O. Orr and Philip M. Cowett, "Desirable characteristics of 16mm entertainment film for Naval use," *Jour. SMPTE, 58:* 245–258, Mar. 1952. See especially p. 249, Use of Sulfide Photoresistive Cell.

Dual Photomagnetic Intermediate Studio Recording

By JOHN G. FRAYNE and JOHN P. LIVADARY

Selected production magnetic tracks are transferred to a recorder which lays down collinear 200-mil push-pull direct-positive variable-area and magnetic tracks. Magnetic stripe is on base of photosensitive emulsion on the opposite edge of film from photo track. The photo track may be used for reviewing, cutting, etc. Re-recording is done from assembled magnetic tracks. This method combines advantages of photo track for editing and provides superior quality of magnetic track. Certain operating economies are made possible by this method.

The use of magnetic recording for original motion picture production has made such great strides since its introduction into the studios three or four years ago that it has now become the almost universal medium for this type of recording. The use of magnetic recording in the subsequent studio operations, such as running of dailies, cutting, editing and re-recording, has been very limited to date. This hesitancy on the part of the studio has been due to many factors, some economic in nature, some imposed by the unavailability of the necessary tools—such as suitable film splicers—and some due to the inevitable inertia in changing over from certain time-honored work practices to new and untried techniques.

Among the latter, the cutting and editing of the opaque magnetic sound track have been stumbling blocks to operators long accustomed to "reading" the visible modulations of either variable-density or variable-area photographic sound tracks. Attempts have been made to ameliorate this situation by superimposing so-called "modulation" writing on the magnetic coating, or, in the case of striped film, on the clear film base area. This writing usually represents a trace of the sound envelope (rather than the individual sound modulations) because of the difficulty of making the writing pen follow any but the lowest of the sound-track frequencies. Consequently, the output of the magnetic sound track is usually rectified before being fed into the pen, and with the aid of some electric filtering a d-c deflection may be obtained for even a high-

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frequency input. This writing usually involves a separate operation, at a reduced speed, to obtain a legible trace.

The method described in this paper retains all the advantages of the standard photographic sound-track studio procedure and combines with it the improved quality and ease of operation associated with magnetic sound recording. This method also achieves from the very start the ultimate objective of using magnetic sound track for re-recording purposes. In this method the original magnetic sound track is transferred by re-recording to a special film consisting of a standard sound-recording photographic emulsion on which is coated a magnetic stripe, and which will be referred to in this paper as photomagnetic film. The location of the magnetic stripe is shown in Fig. 1, which also shows a 200-mil push-pull variable-area track. The latter is in the standard position for a sound-track print even though it is recorded as a direct-positive variable-area track. The magnetic track is in the No. 3 position on the Proposed American Standard PH22.86. The standard position for the direct-positive photographic track is obtained by reversing the film travel in a standard Westrex RA-1231 Recorder. The magnetic track may be reproduced by reversing the film travel in a standard single-track magnetic sound reproducer or in the normal forward direction in a triple-track reproducer.[1]

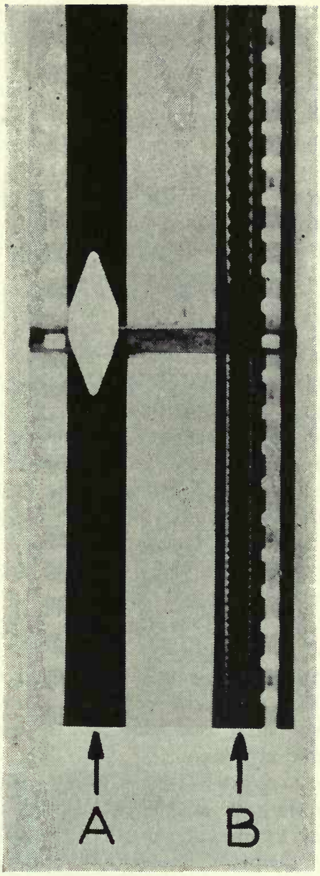

Fig. 1. Photomagnetic film sample: (A) magnetic stripe, showing bloop; (B) photo track.

Having obtained such a film, the photographic track may be used for running dailies and for the regular editing and cutting procedures. The magnetic track may, if desired, be used for dailies, although its primary function is as a re-recording medium. In cutting the sound film standard editing practices are followed on the photographic track, and, since the photographic and magnetic modulations are in exact juxtaposition across the track, a cut across the film insures correct synchronization for both tracks. This method of recording does not involve any drastic change of daily habits for the film editor occasioned by the reading of the magnetic sound track or in the proper interpretation of derived modulation-scribed tracks. Rather, it affords the editor the opportunity of gaining proficiency in the aural editing of magnetic tracks, guided by the parallel photographic track which is always available for reference.

With this technique, no capital investment is required to convert review rooms.

Moviolas or any other screening equipment to magnetic sound reproduction, since the regular photographic sound-reproducing equipment may be used to reproduce either the push-pull or one-half thereof as a standard single track. Only the re-recording equipment required for the final transfer to the release photographic equipment needs to be modified to reproduce from the magnetic track on the composite film.

Dual Recorder

The recorder chosen for this work was the Westrex RA-1231-C Variable-Area Recorder as modified to lay down a 200-mil push-pull direct-positive variable-area track as previously described in the *Journal*.[2] The optical schematic of the direct-positive variable-area modulator is shown in Fig. 2. It includes a check visual monitor and an improved photocell monitor. In the latter the ingenious scheme is employed of using the light transmitted through the ribbons for actuating the photocell monitor, the light reflected from the ribbons being used to expose the photosensitive emulsion.

The recorder was further modified by adding a magnetic recording kit similar to that described in the March 1950 *Journal*.[3] Since the film travel is in the reverse direction, the monitor head has been moved as shown in Fig. 3 to a position above the recording head, instead of to the customary position below and to the right of the latter. The location of the recording head at the drum position makes it possible to make the magnetic and photographic lines of translation exactly collinear. In fact, the location of the recording head at any other position in the recording machine would defeat the purpose of this dual-recording technique. One of the problems encountered in this recorder was the tendency to partial magnetization of the recording head by the stray field from the light-valve permanent magnet. This was somewhat alleviated by placing a sheet of mu-metal between the modulator and film compartments of the recorder. Under this recording condition, an overall signal-to-noise ratio of about 55 db is readily obtained on the magnetic track. Since this is considered satisfactory in view of the ultimate transfer to a standard photographic release track, no further isolation of the disturbing source of magnetization seems to be immediately warranted.

Film

The film used to date in this process is the Eastman Fine Grain Sound Recording Safety Film, Type 5372 (35 mm), variable-area type film with the magnetic stripe added to the base side of the photosensitive film. The pioneering work in the coating of this raw stock was carried out by Reeves Soundcraft Corp., and in spite of the rather hazardous process of working with a light-sensitive film the production of the early batches of the dual-purpose film has been singularly free of serious defects. Further experience should tend to make this operation a purely routine affair. The processing of the film is handled in the film laboratory without any precautions other than those dictated by normal operating practice for the proper development of variable-area tracks. No damage to the magnetic stripe by the photographic developing process has been observed.

The Record-Reproduce Transmission System

The transmission system of the photographic-magnetic transfer channel in use at Columbia Pictures Corp. is shown in block-schematic form in Fig. 4. The original magnetic recording is reproduced by a modified RA-1251 Rerecorder, the signal being fed to a dividing network through a level-control attenuator and line amplifier. The dividing network provides two input signals, one of which is recorded by

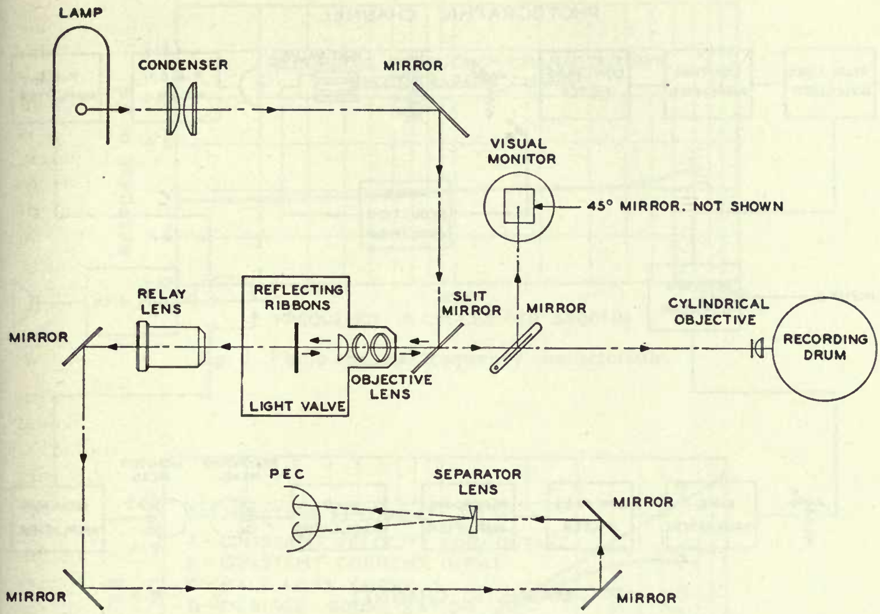

Fig. 2. Variable-area modulator optical schematic.

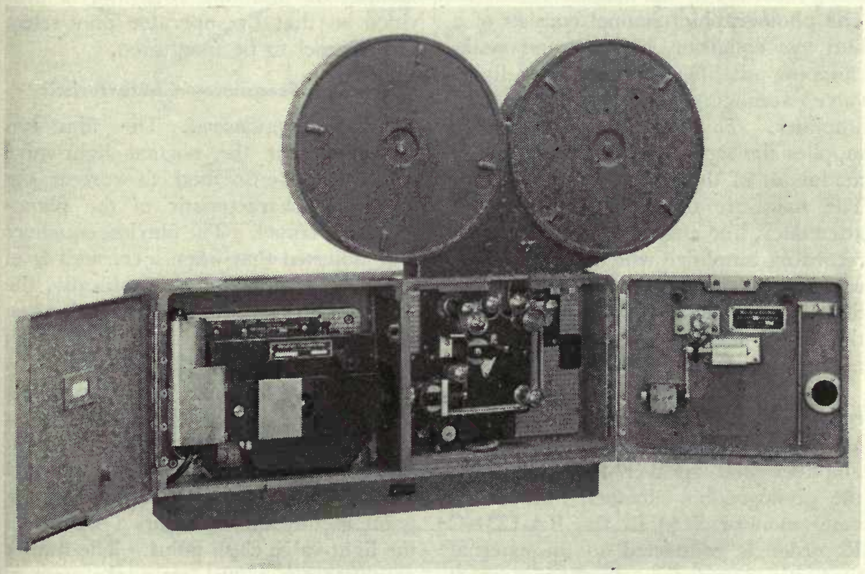

Fig. 3. Dual photomagnetic recorder.

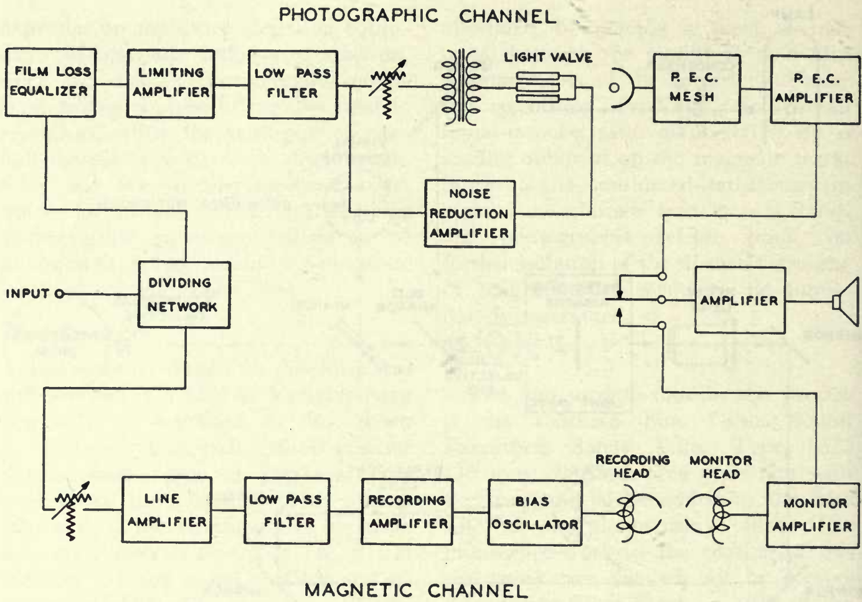

Fig. 4. Block schematic of dual recording channel.

the photographic channel, the second being recorded by the magnetic channel. The photographic channel consists of a film loss equalizer, limiting and peak-chopping amplifier, low-pass filter, light-valve attenuator and noise-reduction amplifier. This photographic channel supplies the signal for the photographic modulator of the RA-1231-C Recorder. The magnetic channel consists of an attenuator, line amplifier, low-pass filter, recording amplifier which also provides equalization, and a bias oscillator and filter. The magnetic channel supplies the signal for the magnetic recording head in the RA-1231-C Recorder.

The PEC mesh of the RA-1231-C Recorder is connected to an external amplifier which in turn feeds the monitor amplifier and speaker for monitoring the photographic channel. The magnetic monitor head in the RA-1231-C Recorder is connected to an external magnetic-reproducer amplifier which feeds the monitor amplifier and speaker so that the magnetic channel may be monitored. Suitable switching is provided so that the operator may select the channel to be monitored.

Recording Frequency Characteristic

Photographic Channel. The film loss equalizer plus the normal light-valve resonance rise is used to correct the frequency characteristic of the photographic channel. The film loss equalizer is so adjusted that when a constant level signal is recorded photographically, the resultant film will reproduce "flat" when referenced to the Research Council standard frequency film ASFA-2 5-521-A. The frequency response of the photographic channel from the input to the light-valve transformer is shown in Fig. 5. The film recording channel is so adjusted that the peak chopping point of the limiter occurs 1 db below the light-valve clash point. The limiter amplifier has a 20:1 ratio, the start of limiting being 2 db below the peak

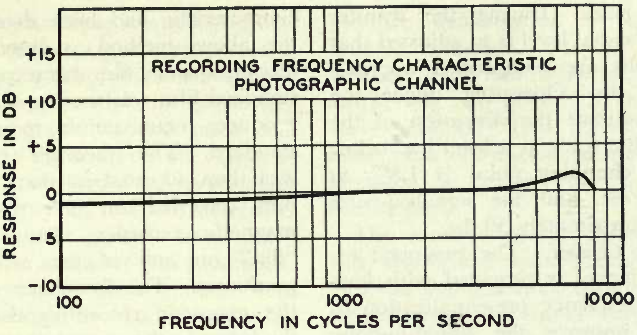

Fig. 5. Photo channel frequency characteristic.

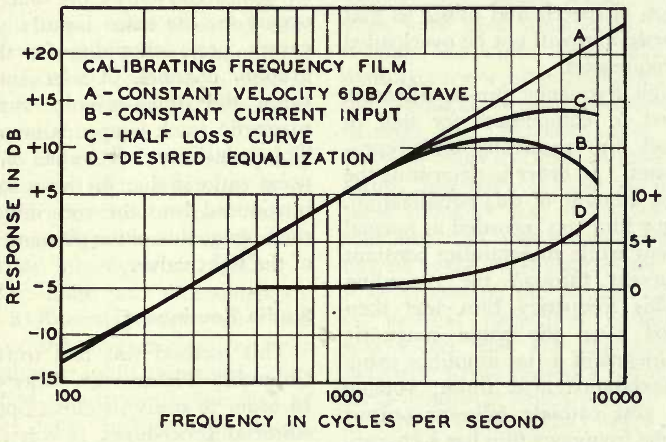

Fig. 6. Magnetic calibrating frequency film.

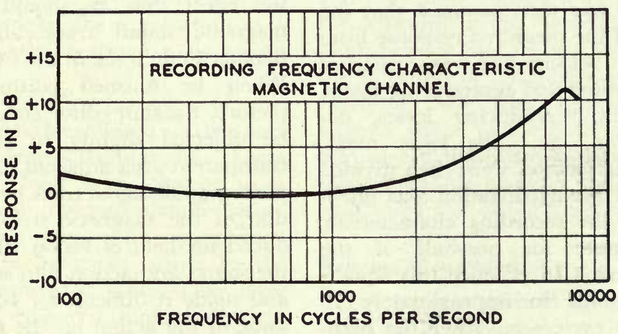

Fig. 7. Magnetic-channel frequency characteristic.

chopping point. During the transfer operation, signal level is so adjusted that peak signals are compressed approximately 4 db. Operating under the above conditions the distortion of the photographic track at a level just below the peak chopping point is 1.8% at 400 cycle/sec. and the signal-to-noise ratio is approximately 50 db.

Magnetic Channel. The magnetic recording channel is provided with low- and high-frequency pre-equalization in order to improve the signal-to-noise ratio of the magnetic track. The low frequency pre-equalization amounts to 5 db at 50 cycle/sec, this amount of equalization being based on the energy distribution of speech and music so that the magnetic film will not be overloaded at low frequencies.

The high frequency pre-equalization is adjusted to compensate for half of the overall film recording and reproducing losses. In order to determine the shape and amount of this equalization, a frequency film was recorded at normal bias current while maintaining constant audio current through the recording head. This frequency film was then reproduced over the same magnetic head by means of a flat amplifier using a high-impedance grid input, voltage amplifier and cathode follower output stage. The frequency film has a characteristic similar to that shown in Fig. 6. On this characteristic curve a constant velocity (6 db per octave) line A-B was drawn. It was then assumed that the deviation of the measured response from the constant velocity line was a measure of the recording and reproducing losses, such as slit reproducing losses, demagnetization, etc. The losses measured by this method were then divided in half and pre-equalization was introduced into the recording characteristic to compensate for one-half of the measured loss. In practice this equalization amounts to approximately 10 db at 8000 cycle/sec. After the high- and low-frequency pre-equalization characteristic had been determined by the above method, a standard three-track frequency film was recorded. This standard film was used to adjust all reproducer equalization to a common standard. The recorder equalization was then adjusted so that a magnetic film recorded on the photographic-magnetic recorder would reproduce "flat" on any of the calibrated reproducers. The frequency response of the magnetic recording channel from the input to the output of the recording amplifier is shown in Fig. 7.

The gain of the magnetic channel is so adjusted that the 1% distortion point at 400 cycle/sec of the magnetic film occurs for the same input signal which causes peak chopping in the photographic channel. Under these conditions, the signal-to-noise ratio of the magnetic track is approximately 55 db. This relatively low value of signal-to-noise ratio is due to the magnetic flux introduced into the recording head by the leakage flux of the permanent magnet of the light valve.

Studio Routines

This method was first introduced at Columbia Pictures on May 19, 1952. In order to study its effect upon normal editorial procedures, it was introduced without any forewarning to the editorial department. The only information transmitted to the film editor was to the effect that he should ignore the magnetic sound track and edit the photographic track in the usual manner. When he finished editing the first picture, the film editor commented that he objected slightly to reducing the transparent area adjacent to the normal photographic sound track by the application of the magnetic stripe. This reduced his field of vision while running the sound and action film superimposed and made it difficult for him to follow some of the action on the fringe of the picture frame.

During re-recording it was found that the quality of the magnetic stripe was a faithful copy of the original magnetic recording. Apparently the processing of the photographic sound track had resulted in no ill effects on the magnetic track, which confirmed pre-production tests during which the characteristics of the magnetic sound track were checked before and after film processing.

Normal overlap film splices were used in splicing this film. In running the magnetic sound track some of these splices proved to be silent and some noisy. It was found that magnetized shears and cutting blades of the regular film splicers were mostly responsible for this effect. It was also observed that certain splices had a microphonic effect upon the magnetic head due to the impact of the lower edge of the film splice upon the magnetic head.

This last observation revealed that film splices were silent when made in one particular direction, which luckily happened to be the normal way of making splices on photographic film.

The splice noise was eliminated by punching a diamond-shape hole (see Fig. 1) over the magnetic splice, as is done on photographic negatives. Another method was to notch the film at each splice and momentarily short-circuit the recording system by a micro-switch operated from these notches. Still another solution involved the momentary lifting of the splice from the magnetic head by the application of a triangular piece of adhesive paper on the splice.

Some of the first samples of this photographic film exhibited severe edge-wave and spoking of the film roll. These defects have long been present to a minor degree in standard motion picture film but were apparently exaggerated in adding the magnetic stripe to the base of the sensitized film. They have been largely removed through the cooperation of the manufacturer of the striping process. Another difficulty, pressure densitization of the photographic emulsion, due to too tight winding of the film rolls after adding the stripe, was also present in some of the early samples. This defect, too, has since been eliminated by more careful attention to proper rewinding of the coated film.

The location of the balance stripe was also given some thought. Some film was manufactured with the balance stripe along the outer edge of the sprocket holes on the side of the photographic sound track. Other film was manufactured with the balance stripe located along the inner edge of the photographic sound track. Both positions were tried since at the beginning it was not quite clear whether the manufacturer's edge numbers on this film would be of any importance in film editing, and provision was therefore made to leave the edge numbers visible. Later, however, it was decided that these numbers had no particular significance and the balance stripe was moved to the outer edge of the film.

In projecting the photographic track on normal projection equipment, it was found that the thickness of the magnetic stripe caused a slightly out-of-focus condition which resulted in a loss of 1 db at 7,000 cycles. This was more evident when the balance stripe was placed adjacent to the photographic sound track because the magnetic stripe and the balance stripe were both riding the scanning drum, which caused the photographic film to be out of focus by the thickness of the magnetic emulsion. However, the later removal of the balance stripe to the outer edge of the film placed the photographic track in a more favorable position and practically eliminated this out-of-focus condition.

Benefits of the Method

The benefits derived by this method so far are as follows:

1. It eliminates the need for introduc-

ing magnetic equipment in the projection rooms.

2. It introduces 100% magnetic operation without causing any disturbance in the editorial department.

3. It eliminates photographic re-recording masters and substitutes a magnetic sound track for re-recording purposes.

Economic Considerations

Experience with this recording method at Columbia Pictures has shown that there is a definite reduction in cost as compared to the normal negative-positive photographic recording method as practiced at the studio. However, due to the downward trend in costs of magnetic striped film and also due to such alternate methods as the use of $17\frac{1}{2}$mm instead of 35mm and the substitution of a lower-cost fine-grain positive for the premium 5372 emulsion, it is difficult to set down in figures what the ultimate savings might be in the method of recording described in this paper. A considerable saving results from the elimination of master photographic re-recording tracks which amounts to an average figure of $500 per picture at Columbia.

It is too early yet to thoroughly evaluate completely the full effect and future potentialities of this particular method. This method was originally developed as an interim measure designed to promote the gradual education of the film editors at Columbia Pictures in the handling of magnetic films prior to the introduction of 100% magnetic-recording methods. It is quite possible, however, that because of the advantages shown above this method may eventually develop into a strong competitor to the all-magnetic recording method which is the ultimate objective of the motion picture industry.

The authors wish to acknowledge the invaluable aid of Lloyd Russell of Columbia Pictures in getting this recording system into practical use in the studio. They also wish to thank Reeves Soundcraft Corp. for their cooperation in making this film available and in endeavoring to meet the particular studio requirements for the successful operation of this photo-magnetic film method.

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2. L. I. Carey and Frank Moran, "Push-pull direct-positive recording," *Jour. SMPTE, 58:* 67–70, Jan. 1952.
3. G. R. Crane, J. G. Frayne and E. W. Templin, "Supplementary magnetic facilities for photographic sound systems," *Jour. SMPTE, 54:* 315–327, Mar. 1950.
4. Eastman Kodak Company, *Common Cause of Damage to 35mm Release Prints*, 1952.

Discussion

J. E. Aiken (Naval Photographic Center): Many studios prefer the use of variable-density sound tracks. I would like to ask Dr. Frayne if there is any reason why this method may not be used with variable-density sound tracks. While I have the floor, I would like to ask a second question. What precautions should be taken in the film laboratory in processing and are any changes in techniques and equipment required in the film processing laboratory?

Dr. Frayne: There's no reason whatever why you could not use variable-density instead of variable-area, provided that you have a variable-density direct-positive. There was a paper published in the *Journal* about a month ago by O. L. Dupy, which I had the privilege of presenting for him at the Chicago Convention, in which is outlined a direct-positive variable-density system which is currently being used on an experimental basis at M-G-M. If that or some similar method works out, there is no reason why it cannot be used. The problems are the same for either method as far as equipment is

concerned. With regard to the second problem, all I know about the laboratory problem is that I have been assured by Mr. Livadary and the laboratory people at Columbia that no extra precautions have to be taken in handling this film in the laboratory. Does that answer your question?

Mr. Aiken: Thank you.

George Lewin (Signal Corps Photographic Center): Is this type of magnetic film fully as good as a regular full-width magnetic film in sound quality?

Dr. Frayne? I have been assured that the striped film now in production is of comparable quality. At first, I believe, there were some difficulties. I think that somebody in the audience from one of the film-coating companies could answer that question better than I can.

Edward Schmidt (Reeves Soundcraft Corp.): John, you're quite right. The early films did have problems. But I feel that the present product that we manufacture is equivalent to the current full-width 35mm magnetic film, without any question.

Dr. Frayne: Thank you.

Television Facilities of the Canadian Broadcasting Corporation

By J. E. HAYES

This paper describes the television stations which the Canadian Broadcasting Corporation has built in Montreal and Toronto for the inauguration of television broadcasting in Canada. In planning these stations certain special requirements had to be met such as the necessity for programming in two languages in Montreal and the need for producing a relatively large percentage of locally originated shows in both cities.

It might be said that the first official step in the development of a Canadian television service was taken in January 1950 when the Governor-in-Council approved a loan of $4,500,000 to the Canadian Broadcasting Corp. for the purpose of establishing television stations in Montreal and Toronto. Actually, of course, much work had preceded this action. We had kept in close contact with progress in England, France and the United States, and had prepared for our management detailed reports covering technical, program and financial aspects of television. The Board of Governors of the CBC was in a position therefore to make recommendations to the Canadian Government with a full knowledge of the existing television situation in other countries and the probable effect of its impact on Canada.

Detailed engineering work was started immediately and a position of Coordinator of Television established to ensure coordination of the planning of the program, engineering, policy and financial aspects of the project. The duties of this post were undertaken by J. A. Ouimet who was, at that time, Chief Engineer. Appointments were made of the key personnel for both the Montreal and the Toronto stations in order to permit the organization of the operating staff during the period of construction. A senior position, reporting directly to Management, of Director of Television, was established for each location and, under him, positions of equal responsibility, Technical Director and Program Director. These men, with their respective assistants, formed the nucleus of the operating group for each station and under the general guidance of the Coordinator were given the responsibility of developing program plans, determining staff requirements and setting up training and hiring schedules timed to fit with expected completion dates for the stations.

Presented on October 6, 1952, at the Society's Convention at Washington, D.C., by J. E. Hayes, Canadian Broadcasting Corp., P.O. Box 6000, Montreal, Canada.

Throughout all this preliminary work, special emphasis was placed on complete cooperation between program and engineering since it is our conviction that only through such cooperation is it possible to achieve the best results. This teamwork is quite necessary even during the design of the stations since the design engineers must be kept informed regarding program plans in order to be in a position to provide the most suitable equipment. On the other hand program plans must be developed with a consciousness of the cost of technical facilities which may be required by the programs envisaged.

The two stations which are now in operation in Montreal and Toronto are the result of this type of cooperative effort and we believe the result will justify the amount of planning and thought that has gone into their development. Actually, we had hoped to be in operation several months earlier, but shortages of steel for towers, delayed deliveries of electronic components and other incidents of a completely nontechnical nature have hindered our progress.

Technical Facilities: The facilities supplied in the two stations are, in general, the same, although there are certain minor differences which were brought about by local conditions. Basically, each station consists of two studios, film recording and reproducing facilities, a mobile unit, a 5-kw picture transmitter, and a 3-kw sound transmitter. In Toronto this equipment and office space for technical and production personnel are housed in a five-story building located in the center of the city. The antenna, a 6-bay turnstile, is mounted at the top of a 500-ft self-supporting tower which is adjacent to the main building. The transmitter operates on channel 9 (186 to 192 mc) with an effective radiated power of 26 kw.

In Montreal, the transmitter and studios are separated. The television studios are located in a new five-story annex to the Radio-Canada Building, a twelve-story structure which houses our engineering offices and all our sound studios and operations personnel for the Montreal area. The transmitter and antenna are located on top of Mount Royal, which is situated in the center of the city. The tower height of 283 ft (a limit imposed by aviation restrictions) plus the height of the mountain results in an overall antenna height of about 936 ft above average terrain. The transmitter operates on channel 2 (54 to 60 mc) and with a 3-bay turnstile antenna provides an effective radiated power of 16 kw for the picture carrier.

Because of the delay in obtaining the towers, it was found necessary to erect 70-ft temporary masts on top of the transmitter buildings in both cities. Single-bay antennas were erected at the top of these temporary masts in order to permit operation of the stations prior to completion of the main towers.

This rather brief description gives a fairly general picture of the two television installations. A more detailed description of the Montreal station will serve to show the extent of the facilities being provided.

The five-story studio building is 67 × 90 × 46 ft high. It has a cube of 455,000 cu ft, and is of fireproof construction. This building houses two production studios, a film recording and reproducing room, and control rooms, but does not include office space for the technical and production staff of the station.

In the basement there are scenery shops, with woodworking and painting sections, storage space, a room for refrigeration equipment, and dressing rooms. The scenery shops are equipped with power tools, hand tools, and painting facilities necessary for the production of scenery. Paint-spray equipment, a heavy-duty sewing machine, and other necessary tools, are supplied for the production of flats and backdrops.

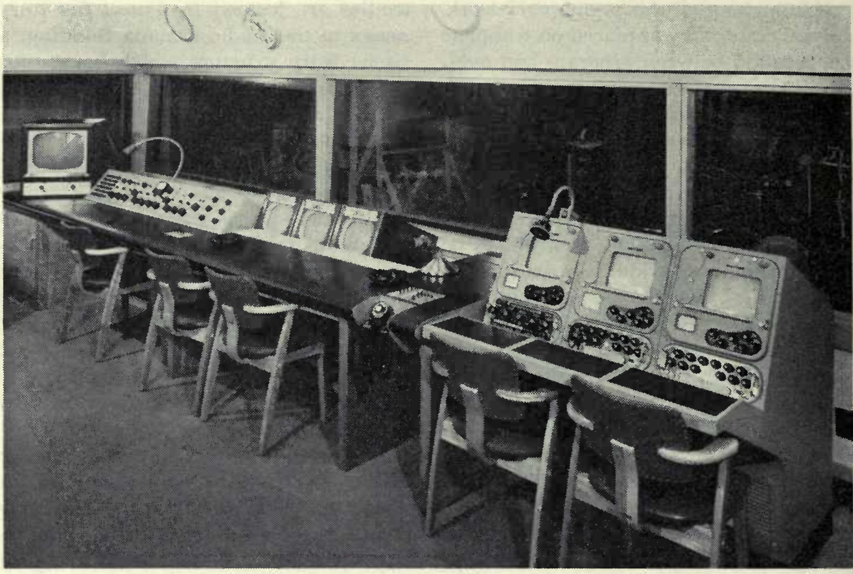

Fig. 1. Control room for the small studio. At the left of the picture is the audio console, then the positions for the program producer and his assistant followed by the technical producer and camera control operator.

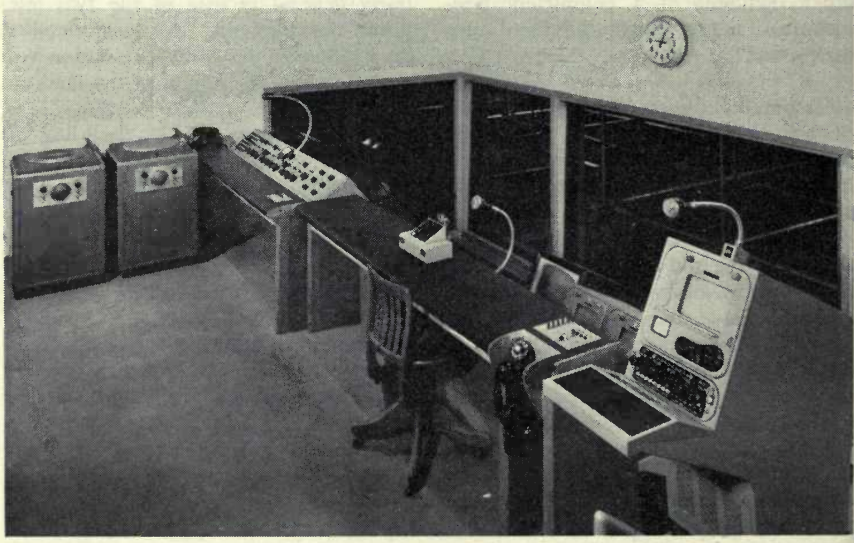

Fig. 2. Control room for the large studio. The audio control position is at the left of the picture; the producer and his assistant work at the central desk. Camera control operators are seated at a lower level. The technical producer operates the camera switching console at the right.

The first floor is occupied by the large studio. The second floor has the control room, observation room, announce booth, and the upper part of the main studio. The third floor has the smaller studio, a storage room for props, a clients' room, an announce booth, and control room. The fourth floor is occupied by the upper part of the small studio, master control room, the film recording and reproducing room, a maintenance shop, film editing room, and additional storage space. Ventilating equipment is located on the fifth floor, which is approximately one half the area of the other floors.

Large Studio: The large studio is 90 × 60 × 25 ft high and occupies two stories. It is equipped with three cameras, one of which is mounted on a small camera crane, and the other two are mounted on pedestal dollies. One large and two small microphone booms are provided, as well as video and audio monitors, and a complete production intercommunication system. The cameras and all the video equipment for both Montreal and Toronto studios were manufactured in England, but are similar in general design and operate on the same standards as equipment available in the United States. The lighting equipment, totalling about 70 units, includes an assortment of scoops, 6-in. and 8-in. spotlights, and a few striplights and fluorescent units. Lighting control panels permit individual switching of 80 circuits, and dimmers allow independent adjustment of 10 different banks of circuits. Pantographs are provided to allow adjustment in a vertical direction of 16 of the lighting units. The control panels and wiring are arranged to permit expansion, since it is expected that the lighting facilities may eventually be approximately double the initial installation.

Small Studio: The small studio, which is 65 × 44 × 19 ft high, occupies part of two stories. It is equipped with units similar to those already described, except that there are only two cameras, one of which is mounted on a small camera crane, and the other on a pedestal dolly. The number of lighting units is approximately one half of those in the larger studio.

No provision has been made in either of these studios for the accommodation of a studio audience, since it is much more economical to use all available space for studio production. Audience participation shows requiring a small audience can, of course, be handled by bringing a limited number of people into the studio for that particular program.

Control Rooms: Each studio has its own control room arranged to overlook as much as possible of the associated studio. The master control room is located on the fourth floor, and has observation windows at one end, to permit visitors to see the equipment without interfering with operations. The control rooms are shown in Figs. 1 and 2, and the master control console in Fig. 3.

Film Recording and Reproducing Facilities: The film recording and reproducing room is located on the fourth floor adjacent to master control. The film reproducing equipment (Fig. 4) is of a new design using an image orthicon camera similar to those in the studios. It includes two 16mm projectors and two slide projectors, all of which can be remotely controlled.

Film recording equipment is provided to permit the recording of television programs on 16mm film. This equipment provides a direct-positive picture from a negative image on the tube. With this equipment only a single print is available, and facilities for producing additional prints will be added later as the need arises.

A magnetic tape recorder is located

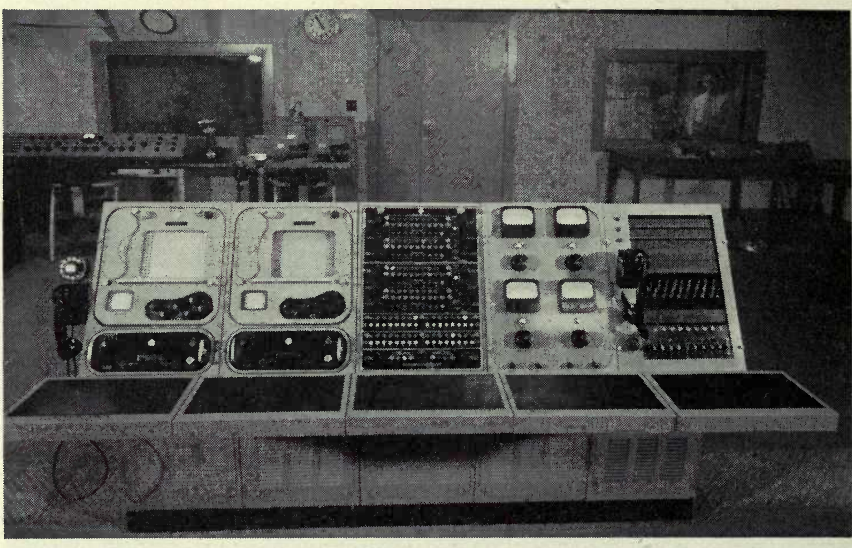

Fig. 3. Master control console. This console has two monitors for incoming programs, and switching, audio and order wire panels. The console accepts audio and video signals from the studios, film reproducing equipment, network or mobile unit microwave. These signals may then be routed to the transmitter, film recording equipment or network as required.

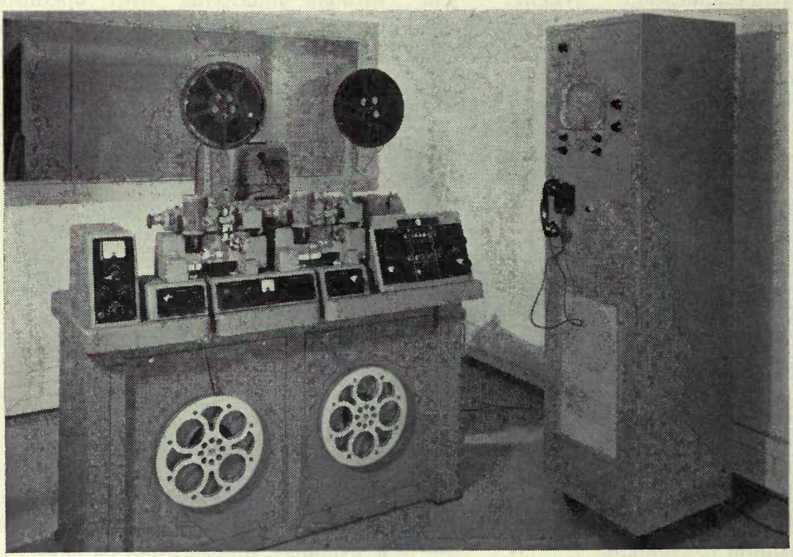

Fig. 4. Film reproducing equipment and monitor rack. This equipment combines two 16mm projectors and two slide projectors and feeds the optical output from the projectors into an image orthicon camera visible at the rear of the unit.

in the film recording and reproducing room, to be used, as required, for the recording and playback of commentaries for newsreels. It may also be used for recording the sound portion of film recordings as a protection against possible loss of the optically recorded sound track during recording or processing.

Photographic Equipment: A Houston processor for developing 16mm film is installed in the Toronto station to permit processing of our film recordings, newsreels, and other 16mm films. A second processor will be installed in Montreal if the load becomes sufficiently heavy to justify the additional unit. There is also an assortment of auxiliary photographic equipment to facilitate satisfactory editing, titling and cleaning of films. 16mm motion picture cameras are available for taking newsreels, drama fills, and other similar pictures. Still cameras, an enlarger and developing equipment are provided for the purpose of making slides and for various other uses around the studios.

Mobile Unit: A mobile unit equipped with three camera chains, a microwave relay transmitter, and all necessary auxiliary equipment is used for televising sports, special events and other subjects outside the studios.

Normally, the microwave transmitter for the mobile unit relays the signal back to a receiving point on top of the Radio-Canada Building, but in the event that a line-of-sight path does not exist between the remote location and this receiving point, a second receiving point is available on the transmitting tower.

Transmitter Building: The Montreal transmitter building (Fig. 5) is located on the top of Mount Royal on a site which has been leased to us by the City. The building is large enough to house two 5-kw transmitters with the associated 3-kw sound transmitters and in addition, the two 3-kw frequency modulated VHF transmitters which are at present operating from the Keefer Building in Montreal. Some extra space has been set aside to permit future power increases of the television transmitters.

The antenna tower is located adjacent to the transmitter building. At a height of 120 ft above the base there is a platform to support the microwave receiving equipment to be used, when required, with the mobile unit. Above this is a straight section of tower designed to take a 6-bay "super-gain" type antenna to be used in conjunction with a future second television transmitter on channel 6. Then follow two "pylon" type antennas for the two frequency-modulated transmitters and finally, at the top, the 3-bay turnstile antenna for the present television transmitter.

Television Network: The CBC has entered into a contract with the Bell Telephone Company of Canada for a television network connecting Toronto and Montreal via Ottawa and, as well, for a link with the United States television networks via Buffalo, N.Y. A chain of microwave relay stations is under construction along the 374-mile route and, although it is not expected that the complete network will be ready for use before May 1953, the section between Buffalo and Toronto is now in operation. It appears probable that this network could be extended eastward as far as Quebec City and westward as for as Windsor, Ontario, before very long, but a coast-to-coast network across Canada seems to be in the somewhat more distant future. Plans are now underway for the construction of television stations in Vancouver, Winnipeg, Ottawa and Halifax. The Ottawa station will normally be fed via the network from the Montreal and Toronto production centers, but will have facilities for originating programs of special interest from the Capital City. The stations in Vancouver, Winnipeg and

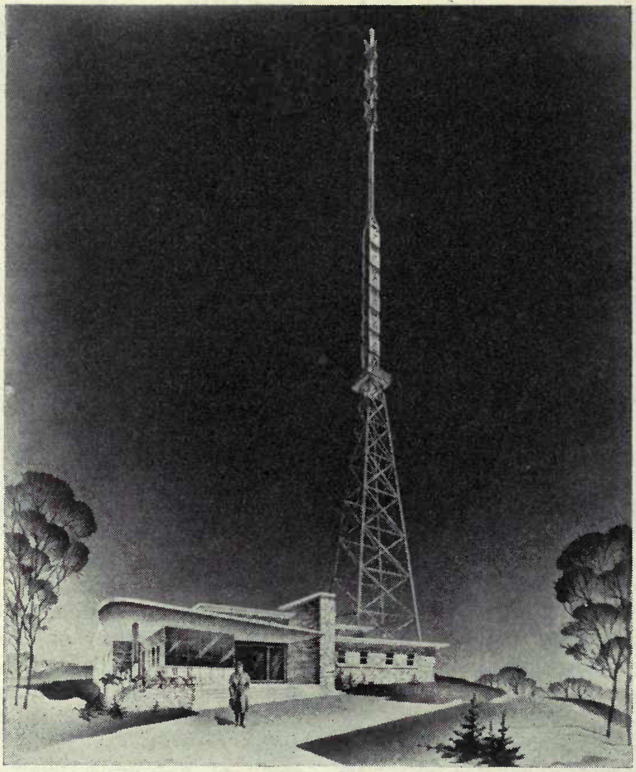

Fig. 5. Transmitter building and antenna structure. The transmitter is located on top of Mount Royal. The turnstile antenna at the top is for the present television transmitter on channel 2. The tubular section consists of two pylon antennas for frequency modulation transmitters. The illustration also shows an antenna for a future transmitter on channel 6. The balcony will support a microwave receiving antenna for use in conjunction with the mobile unit at times when the latter is not within line-of-sight of the studio building.

Halifax will depend on kinescope recordings of Montreal and Toronto productions for most of their schedule, but they will have sufficient facilities for a limited amount of local production.

Program Plans: The recent report of the Royal Commission on National Development in the Arts, Letters and Sciences, more popularly known as the Massey Report, made certain recommendations with regard to the objectives which should determine the choice of material for Canadian radio and television programs. Guided by these recommendations, the CBC intends to make full use of this new and tremendously effective means of expression in the development of Canadian talent and ideas. We believe that it should be used not only as a means of entertainment, but also as a medium for the awakening of a greater appreciation and a better understanding of the more important fields of human endeavour.

The incorporation of this ideal into

a balanced and diversified program schedule requires that the CBC should keep control over the type and quality of all programs it carries. Consequently, commercially sponsored programs will be accepted only when the CBC considers them to be of sufficiently high quality and of suitable content.

Programs are being produced in two languages — English in Toronto and French and some English in Montreal. In addition, the film-recording equipment permits an exchange of programs between the two cities prior to the completion of the microwave network. Experience in sound broadcasting has proven that a bilingual program service is not entirely satisfactory to the majority of listeners, and it is expected that before long a second transmitter will be installed in Montreal to permit independent programs for the French and English viewers. The completion of the network between Toronto and Montreal will make the addition of the second transmitter a logical step. This will not be too difficult to do from a technical standpoint since the layout of the existing equipment has been made in such a manner that the second transmitter with its associated facilities may be added and integrated with the existing equipment.

The two stations began a limited television service during August and the official inauguration of the service took place early in September. The initial program schedule is being limited to approximately three hours in the evening with the expectation that the number of hours will be increased gradually as the service develops.

Discussion

Louie L. Lewis (*WOI-TV*, *Ames*, *Iowa*): Are you going to distribute your programs by relay only, or are you going to distribute them by kinescope also?

Mr. Hayes: We will have to use kinescope recordings to feed Winnipeg, Vancouver and the Maritimes Station. We foresee the microwave network extending east of Montreal to Quebec City and west of Toronto as far as Windsor, but it may not be economical to extend it farther. At present we are exchanging programs between Montreal and Toronto because the network is not yet operating between these cities.

Mr. Lewis: Are you going to make positives and negatives then, and make copies?

Mr. Hayes: We expect to do so as soon as additional stations are in operation. For the moment we are not making any prints but are sending the one and only copy from one station to the other.

Barton Kreuzer (*RCA*, *Camden*, *N.J.*): How many stations of the Canadian Broadcasting Corporation are operating now, TV stations?

Mr. Hayes: Two. Just the one in Montreal and the one in Toronto, and we have four more under construction.

Mr. Kreuzer: Where are those four?

Mr. Hayes: Winnipeg, Vancouver, Ottawa and one in the Maritimes. Actually the physical construction hasn't started, but we are locating sites and carrying out the engineering on these stations.

Use of Ansco Color Film in Commercial Production

By REID H. RAY

The selection of a 35mm color film for the documentary or commercial motion picture producer is a problem of choosing an economical and, from a processing standpoint, a practical type of color film. Both color and black-and-white (35mm and/or 16mm) are sometimes required and a color film which adequately fills such requirements is described here.

Documentary and commercial motion picture producers frequently must supply to their sponsors 35mm and 16mm *color* prints, and for television either 35mm or 16mm *black-and-white* prints. A color film which might be used for multiple purposes would be an economical as well as a practical medium. Production time would be saved, as one crew, with a single camera setup, could produce a master 35mm color negative.

An acceptable 35mm negative-positive type of color film, which meets the requirements of such multiple duty, has been in use at our studio since April 1951. From the one original color negative, four types of release prints have been made (Fig. 1):

1. 35mm color prints,
2. 16mm color prints,
3. 35mm black-and-white prints, and
4. 16mm black-and-white prints.

Presented on October 18, 1951, at the Society's Convention at Hollywood, Calif., by Reid H. Ray, Reid H. Ray Film Industries, Inc., 2269 Ford Parkway, St. Paul 1, Minn.

The material used is "Ansco 35mm Color Camera Film, Type 843, Daylight Balance." This film supersedes Ansco Type 735, a reversible color material which was discussed by the author in a previous paper published in the *Journal*.[1] The characteristics of this color negative have been described in the *Journal*.[2] This paper will describe the use of this color film in the commercial field. (A demonstration reel was shown at the conclusion of the paper.)

The speed of Type 843 Ansco Color Negative is rated at ASA 10 and an ultraviolet 16 filter is recommended for both interior and exterior photography. Arc illumination is used for interiors with Y-1 correction filters on high-intensity arcs. Both incident and reflected light readings are taken in various locations on the set to check evenness of illumination. To achieve a warmer tone in a background, 5-kw or 2-kw solar spots may be added to supplement the key- and backlighting from arcs.

For exterior photography with this type of color film, as in all color work, bright, clear sunlight is a prime requisite, and generally the rule of "the sun

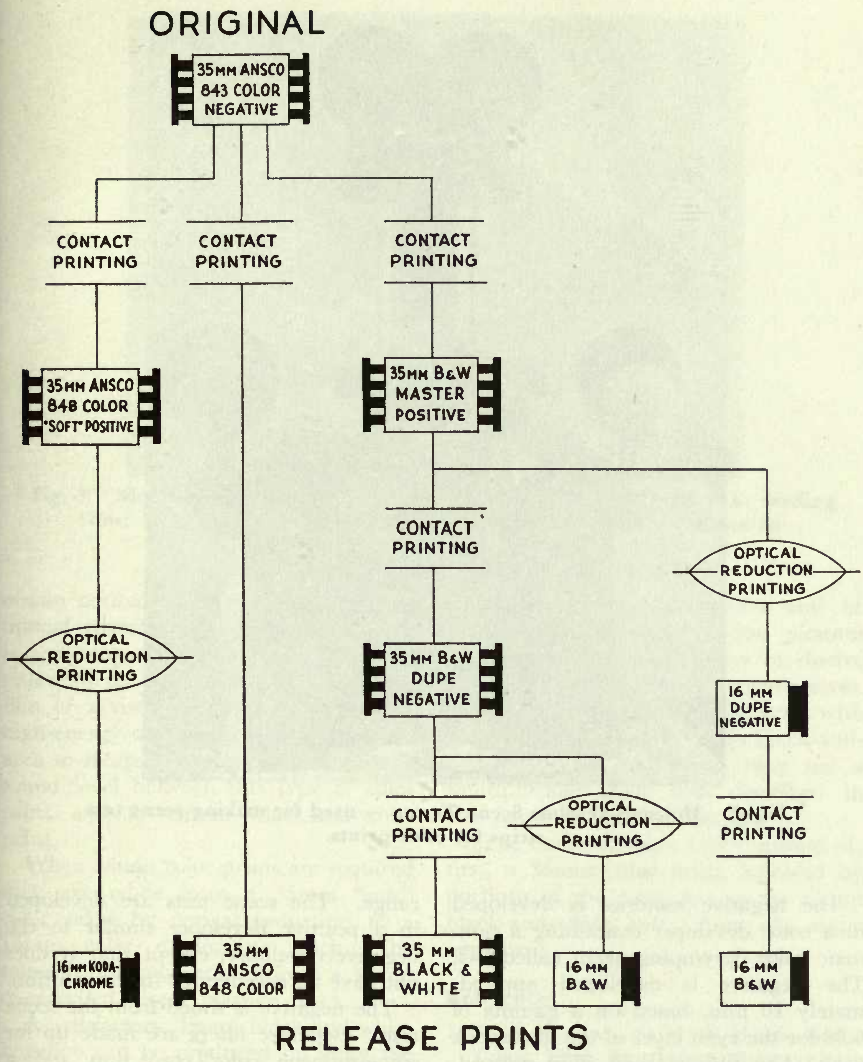

Fig. 1. Methods of release printing from Ansco 843 Color Negative.

behind the camera" holds. However, very pleasing and excellent results have been achieved with sidelighting. Close-ups of characters completely back-lighted by the sun, and frontlighted by booster lights or aluminum-foil reflectors show good latitude in the flesh tones.

Makeup used for interior photography for men is Max Factor No. 27 Pancake sparingly applied. For women, ordinary street makeup is recommended.

The exposed negative material which our studio produces is sent to the Houston Color Film Laboratories for developing and printing. A brief summary of these processes are[3]:

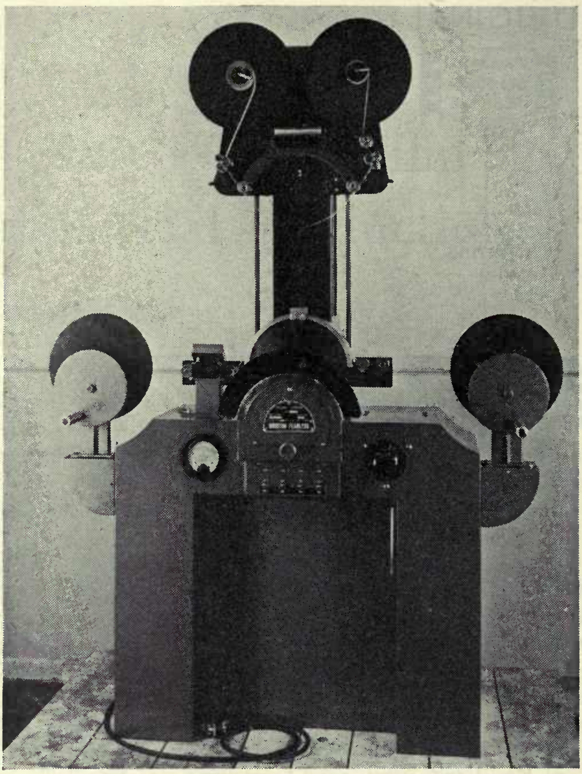

Fig. 2. Houston-Fearless Scene Tester — used for making scene test strips for color prints.

The negative material is developed in a color developer containing a nontoxic color developing agent called S-5. The negative is developed approximately 10 min, based on a gamma of 0.85 for the cyan layer of the monopack film. The film is then short-stopped, hardened, washed, bleached, washed, hypoed, washed and dried.

A scene test for prints from Ansco 843 Negative is similar to a cinex, the main difference being that each frame on the strip is made from a different filter balance, but each frame receives the same printing light intensity. This necessitates three tests being made on each scene, generally three printer points apart, in order to give a density range. The scene tests are developed in a positive developer similar to the negative developer, except that it does not have an accellerator in the solution.

The negative is timed from the scene tests. Separate filters are made up for scene-to-scene color correction and a modified Bell & Howell printer with an automatic filter changer handles the filter combinations (Fig. 3). This filter change is made in conjunction with the notch used for the printer light changes.

The positive stock used is Ansco Type 848 and is developed to a gamma of 2.30 on the red record, being the cyan layer.

The sound is printed from a black-and-white negative track. In order to

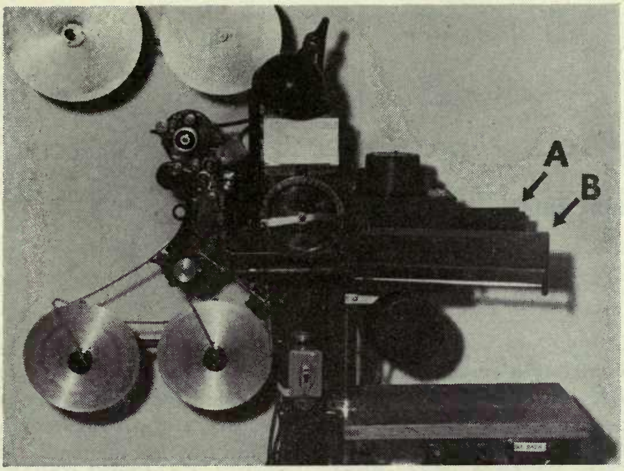

Fig. 3. Modified Bell & Howell Model D Printer with filter bins. A: feeding bin; B: receiving bin. Filter passes from feeding bin to position in front of light, to receiving bin.

obtain normal transmission through the optical system, since the positive stock is a monopack film, it is necessary to redevelop the track area with an application of a viscous solution containing a high-energy developer. With the track area so treated there is no difference in sound level between this type of color print and a normal black-and-white print.

When 16mm color prints are required they are made from a 35mm "soft" color print by optical reduction to a 16mm color duplicating stock. The sound is optically reduced from a 35mm re-recorded direct positive track.

A satisfactory 35mm black-and-white negative can be produced by using the original color negative to print a fine-grain master print on Eastman 5365 stock and by developing this to a gamma of 1.2. From this, a duplicate negative is made on Eastman 5203 or similar duplicating negative material. This duplicate negative is developed to a gamma of 0.66.

The commercial producer works without benefit of large budgets and he must turn out color motion pictures under conditions not always conducive to extensive production conveniences. The producer who wishes to operate with a minimum crew and regular black-and-white camera equipment, may use a multipurpose color film described in this paper to good advantage.

(The demonstration reel consisted of: first, a 35mm color print, followed by portions of the same footage in 35mm black-and-white print from the dupe negative.)

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2. Herman H. Duerr, "The Ansco Color Negative-Positive Process for motion pictures," *Jour. SMPTE, 58:* 465–479, June 1952.
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A Fast-Acting Exposure Control System for Color Motion Picture Printing

By JOHN G. STREIFFERT

An illuminating system in a contact-printer for color motion pictures is described. Light from a single lamp is divided into three beams which are independently filtered, controlled in intensity, and projected onto the printer aperture. Intensities of the red, green and blue components of the exposing light are measured continuously and photoelectrically and compared with reference voltages which are the analogs of the desired intensities and which are controlled by a perforated tape according to the predetermined requirements of each scene to be printed. Any errors between measured intensities and desired intensities, i.e., between photocell outputs and reference voltages, are amplified and applied to servomotors which rotate vanes in the respective beams until the correct intensities are established. A response time of the order of 1/50 sec has been achieved, and the intensity of the printing light is substantially independent of lamp current and age. A manual control on each of the reference voltages provides for emulsion-to-emulsion variations in print stock.

An illuminating system in a continuous contact printer used for making motion picture color prints must fulfill many requirements. The more difficult requirements to attain are:

1. Sufficient illumination to expose the color positive material at a printing speed of at least 100 fpm.

2. Provision for control of exposure and/or color balance to compensate for scene-to-scene variations in negative density and color balance and for emulsion-to-emulsion variations of the positive material. The change in exposure or color balance should be made in a sufficiently short time so as not to be perceptible in the projected picture. Ideally, this change should occur within the frame line. In practice, an operating time of one frame is considered satisfactory, provided there is no overshoot in the system which would cause one frame to be noticeably lighter than adjacent frames.

In addition to these two requirements, it is desirable that the exposure and color balance be substantially independent of the operating voltage and the age of the lamp; that the power consumption of the light source be moderate; and that the optical, electrical and mechanical elements of the system be simple and reliable.

An optical and exposure control

Communication No. 1517 from Kodak Research Laboratories, a paper presented on October 8, 1952, at the Society's Convention at Washington, D.C., by John G. Streiffert, Eastman Kodak Co., Kodak Park Works, Rochester 4, N.Y.

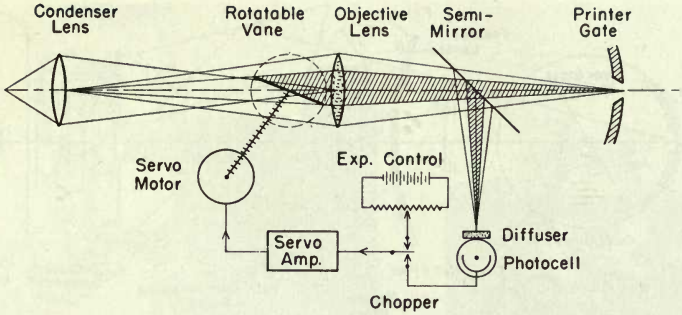

Fig. 1. Schematic drawing of a projection-type optical system with servocontrol of intensity at printer gate.

system designed to meet these requirements is described below.

A simple projection-type optical system with a high-aperture condenser lens and a high-wattage lamp is illustrated schematically in Fig. 1. The condenser lens forms an image of the lamp filament in the objective lens, and the objective lens, in turn, forms an image of the uniformly illuminated condenser lens in the printer aperture. One method of controlling the intensity of illumination at the printer aperture without affecting uniformity is to change the aperture of the objective lens by means of an iris diaphragm or other mechanical masking means, such as the rotatable vane placed near the lens (Fig. 1).

In general, however, the intensity will not change linearly with changes in position of the iris or the vane, because of the nonuniform structure of the filament image. The necessity for a calibrated relation between intensity and vane position can be obviated by means of a servosystem in which the intensity is measured photoelectrically and adjusted automatically and continuously to the correct value (Fig. 1). This is done by comparing the voltage developed by the photocell with a reference voltage, shown schematically as the output of the potentiometer. Any difference between these voltages is amplified and fed into the servomotor which rotates the vane in a direction to reduce the error. The reference voltage set up by the potentiometer is thus the analog of the desired exposure, and scene-to-scene changes in exposure can be made simply by readjusting this reference voltage.

An additive system of color exposure requires three simultaneous exposures, red, green and blue, whose intensities are controlled individually and preferably independently. In Fig. 2 is shown an optical system in which three beams are derived from adjacent segments of a common condenser lens. Mirrors reflect light from the upper and lower segments of the condenser lens into prisms which direct these beams onto the printer aperture at angles of 15° to the central beam. The sizes of the prisms are chosen to compensate for the difference in path length between the outer and central beams; in this way, identical objective lenses can be used in the three beams. Red, green and blue filters at the objective lenses substantially restrict the exposure of each beam to one of the three color primaries. A beam-splitting mirror reflects a small fraction of the filtered light onto an opal glass which acts as an integrator. Beneath the opal glass are three photocells with red, green and blue filters over them. The output voltages of the three photocells are

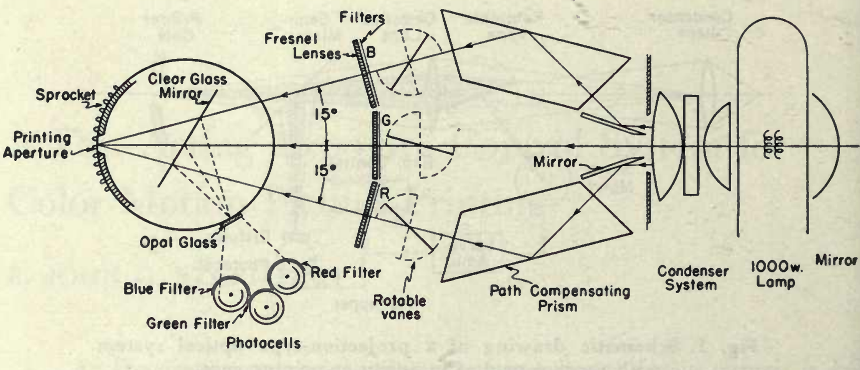

Fig. 2. Schematic drawing of projection-type optical system for controlled additive trichromatic illumination using a single lamp.

compared with three reference voltages, which are the analogs of the desired red, green and blue exposures. Any difference between photocell and reference voltage is amplified by one of three amplifiers and applied to the appropriate servomotor to reduce that difference to zero.

Figure 3 shows a Bell & Howell Model D Printer which has been modified to incorporate the optical system shown in Fig. 2. The outer half of the sprocket was removed to eliminate interference of the sprocket hub with the central light beam. The original light-control shutter mechanism was discarded. In its place a steel block was provided which carries bearings for a film-driven flange which supports the outer edge of the film in place of the original outer half of the sprocket.

The original cylindrical lamphouse has been replaced with a square box which houses the lamp and the optical system. The cylindrical housing on the front of this box houses one of the servomotors. The other two motors are on the rear side of the box. At the extreme right is the electronic complement consisting of the power supply below, above that the amplifier box, and on top a tape-controlled contactor. This contactor reads timing information which is stored in the form of an array of holes punched in a strip of 16mm film.

Figure 4 is an interior view of the lamphouse showing the optical system. Two of the rotatable vanes can be seen to the left of the prisms. The third is seen in the foreground protruding from the hinged cover. The outer film-supporting flange has been removed to show the plate which holds the beam-splitting mirror on its back side. The photocell enclosure has also been removed to show the three photocells beneath the sprocket enclosure.

The 16mm control tape is advanced, one frame at each scene change, by means of a solenoid to establish a new set of reference voltages. In the amplifier circuit of Fig. 5, the tape-controlled contactor controls a battery of fifteen relays, five for each color, which, in turn, control attenuators in the reference voltage circuits. These attenuators are calculated to provide attenuations of 0.4, 0.8, 1.6, 3.2 and 6.4 db, which are equivalent to exposure changes of 0.02, 0.04, 0.08, 0.16 and 0.32 log E. If several relays are energized, these attenuations add, so that a total exposure range of 0.62 log E in steps of 0.02 log E is provided for each color. The three knobs shown on the front of the amplifier box, Fig. 3, are

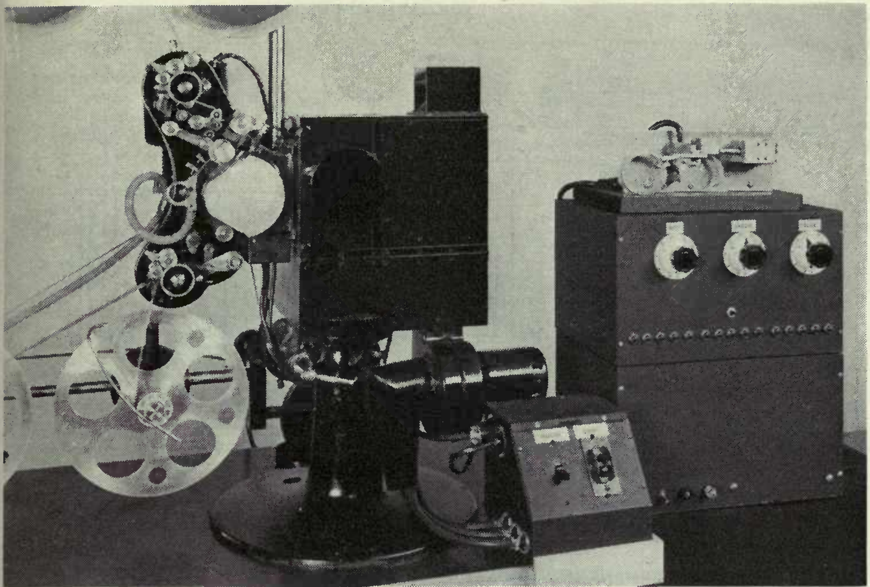

Fig. 3. Printer with new lamphouse. Control tape reader, servoamplifiers, and power supply are at right.

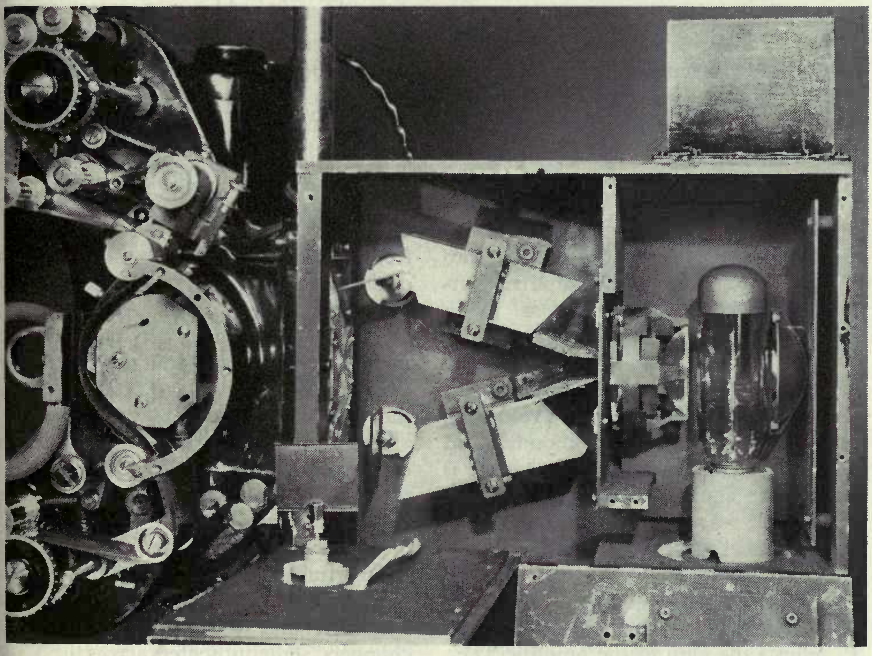

Fig. 4. Interior of lamphouse and optical system.

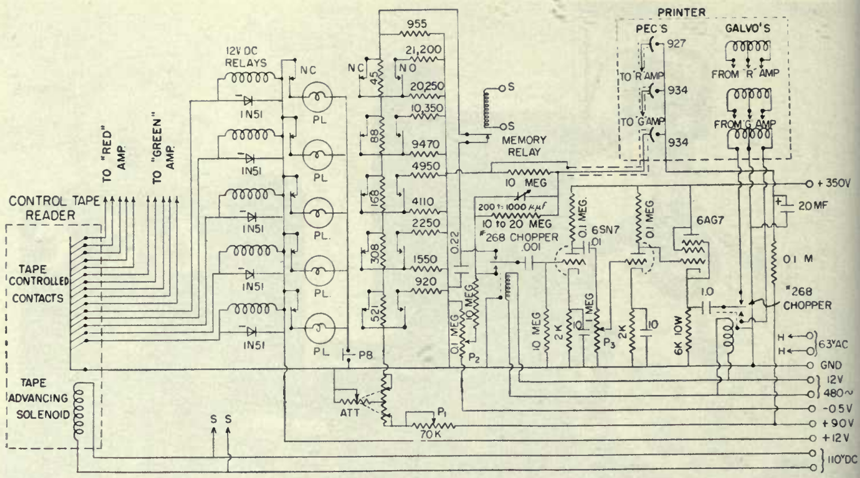

Fig. 5. Schematic circuit of servoamplifiers.

manually controlled attenuators used for setting the operating range of the automatic system and for any compensation for emulsion-to-emulsion differences in the print stock.

The comparison between photocell output and reference voltage is made by means of an electromagnetic chopper. This chopper switches the input to a three-stage amplifier from the photocell output to the reference voltage 480 times per sec. Thus, any unbalance between the photocell output voltage and reference voltage is transformed into a 480-cycle signal. The amplifier output is synchronously rectified by a second chopper.

The servomotors are heavy-duty d'Arsonval galvanometer movements originally designed for graphic recording purposes. The coils are mounted on ball bearings and all restoring torque is removed. The pivot shaft on one end of the coil was extended and the vane mounted directly on this shaft.

Potentiometer P_2 is used for balancing out any voltage generated by the photocell dark current. Potentiometer P_3 adjusts the gain of the amplifier, i.e., the stiffness of the servoloop. It is adjusted for good response without overshoot. An Antihunt network is included between the photocell load resistor and the chopper. This materially improves the transient response of the servosystem. Constants are adjusted for best performance of each amplifier.

The coil of the memory relay is connected in parallel with the solenoid which advances the exposure control tape. Thus, the 0.22-μf condenser connected to the relay contact holds its charge and prevents the servosystem from attempting to follow the operation of the attenuator relays while the control tape is being advanced. After the tape has come to rest in its new position, the memory relay closes and the condenser assumes the new voltage established by the relay-controlled attentuator.

In Fig. 6 is shown the circuit diagram of the power supply. The high-voltage supply is of the choke-input type so that a 480-cycle signal can be picked off the high-voltage rectifier by means of a circuit tuned to the fourth harmonic of the ripple frequency. This signal is amplified and used to drive the six choppers. Potentiometers across the 6.3-v heater circuits and across the 12-v, 480-

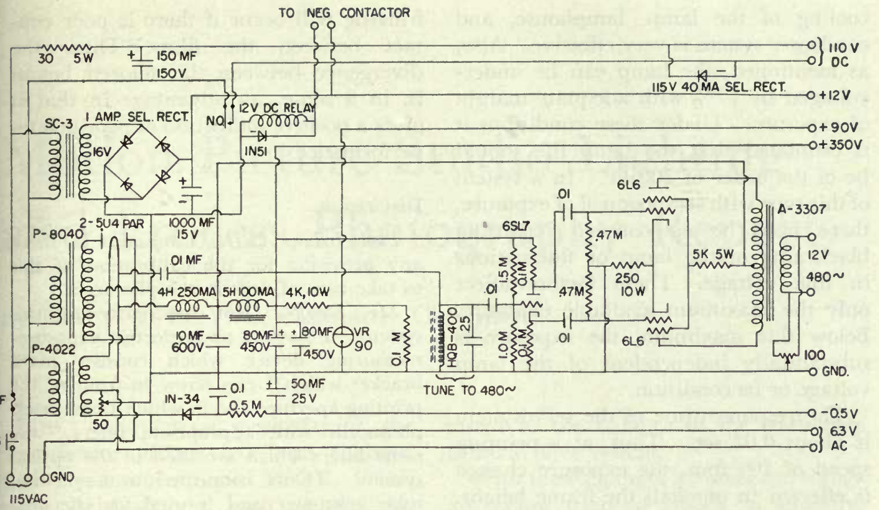

Fig. 6. Schematic circuit of power supply for servoamplifiers.

cycle output are adjusted for minimum residual signal at the output of the amplifiers when the photocells are dark and the outputs of the reference voltage potentiometers are grounded. The germanium and selenium diodes across the relay coils are for contact spark suppression.

The filters associated with the photocells have been chosen so that the spectral sensitivity of the photocell as modified by the filter matches approximately the spectral sensitivity of the respective component of the color print emulsion. For measuring the red exposure, an S1 photosurface and a Kodak Wratten Filter No. 29 are used; for the green, an S4 photosurface and Kodak Wratten Filters Nos. 57A and 16 are used; and for the blue, an S4 photosurface and Kodak Wratten Filters Nos. 47 and 2B are used.

The same relatively sharp-cutting filter combinations are used to filter the three beams in the optical system in order to provide a wide range of control of color balance. If less selective filters were used, a given filter might permit enough leakage of light in an adjacent band so that the exposure in that band could not, in extreme cases, be reduced to a sufficiently low value. This would only occur when printing badly unbalanced negatives. If experience proves that negatives are relatively uniform in color balance, less selective filters can be substituted in the optical system, with a resulting increase in the available overall exposure.

Performance

The normal operating speed of this printer is 100 fpm. The lamp used is a 1000-w, 120-v, T-12 prefocus lamp, operating at 100 v. Under these conditions there is a 0.6 log E margin in exposure above that required from printing a normal negative onto Eastman Color Print Safety Film, Type 5381. As first stated, the tape-controlled exposure adjustment covers 0.62 log E in 0.02 log E steps, or a total of 32 steps. If the system is adjusted so that a normal negative prints at Step 16, then there is a range of ± 0.30 log E available for over- and underexposed negatives.

The lamphouse is cooled with a 200-cfm blower and the air path through the lamphouse and light baffles is designed for a minimum of resistance so that the

cooling of the lamp, lamphouse, and condenser system is very effective. Also, as mentioned, the lamp can be undervoltaged by 17% with adequate margin of exposure. Under these conditions it is estimated that the lamp life should be of the order of 200 hr. In a system of this type with servocontrol of exposure, there need be no concern regarding blackening of the lamp or fluctuations in line voltage. These factors affect only the maximum available exposure. Below this maximum, the exposure is substantially independent of the lamp voltage or its condition.

The response time of the servosystem is about 0.02 sec. Thus, at a printing speed of 100 fpm, the exposure change is effected in one-half the frame height.

Because of the large vertical angle between the three light beams, color fringing will occur if there is poor contact between the films. Thus, the divergence between the colored beams is, in a sense, an advantage in that it gives a positive indication of poor printer performance.

Discussion

Paul Ireland (*EDL Company*): Is there any provision for the calibration of this to take care of drift in the photocell?

Mr. Streiffert: Not inherently in this system. I have a photoelectric exposure-measuring device which consists of a bracket which I can screw in front of the printing aperture and in which I can insert photocells with appropriate filters — the same filters which are used in the optical system. That's connected to a vacuum tube voltmeter and is used for checking exposure from time to time to be sure that it's constant.

Motion Picture Studio Lighting and Process Photography Report

By JOHN W. BOYLE, Committee Chairman

The basic color sensitivity of the Technicolor process has been changed to a color temperature of 3350 K. When white light sources, such as sunlight, are used, the camera optical systems are filtered for proper balance. Incandescent tungsten filament lamps of the proper color temperatures are used unfiltered. When carbon arcs are used mixed with unfiltered tungsten lamps it becomes necessary to filter the carbon arcs to the lower color temperature. This is accomplished by using one MT-2 and one Y-1 filter on all high-intensity arc spotlamps and one MT-2 filter only on Duarc flood lamps. It is possible, however, to filter the camera optical train for sunlight balance and use the carbon-arc floodlamps unfiltered, the high-intensity carbon-arc spotlamps with only a Y-1 light yellow straw filter, and to filter the incandescent lamps with whiterlite filters as in the past. This gives the system a greater latitude so it may be used with incandescent tungsten lamps alone, where desired, at a key-light level as low as 150 ft-c; or with carbon arcs, or sunlight, with a key-light level of 300 ft-c; or with mixed lighting in either case provided the light sources are all adjusted to the balance of the particular camera filter system.

With these changes a number of things are being tried in efforts to simplify, reduce costs and to improve the existing lighting equipment situation.

Many sets are being illuminated almost entirely, or entirely, with incandescent lamps. The 10-kw bulb has again been brought into use (Fig. 1), also the Type T-5 5-kw lamp, which was not previously in favor because of restrictions as to beam spread and overall dimensions, as compared to the Fresnel type 5-kw units.[1]

On large sets the 225-amp carbon-arc "Brute" lamp, filtered to 3350 K, has been used a great deal for long throws and effect lighting.[2]

While the situation caused a drastic change in lighting methods and equipment, some studios are now exploring the values of the new system on both a 3350 K and a white-light basis. In other words, where they have a large set with follow-spots, or where night exteriors are to be photographed, they merely change the filter arrangement in the cameras and shoot on a white-light basis.

Both Eastman and Ansco color negative films are balanced to white light and therefore, with these systems carbon arcs are used for "booster" lights outside as well as for interiors. When in-

A report submitted on September 4, 1952 by the Committee's Chairman, John W. Boyle, Director of Photography, 139½ S. Doheny Dr., Los Angeles 48, Calif.

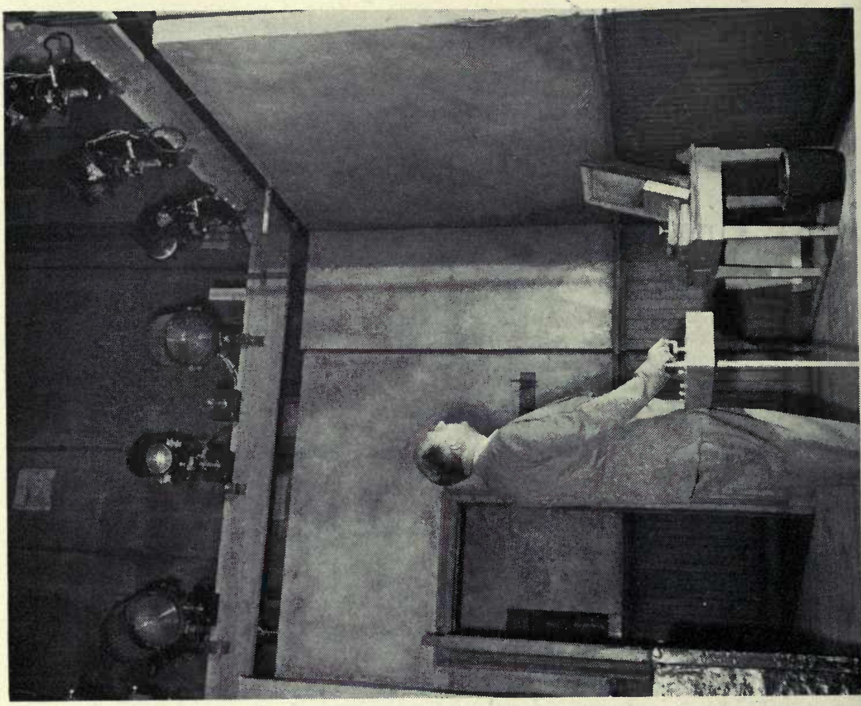

Fig. 2. Paramount Pictures' system of remote-controlled incandescent studio lamps.

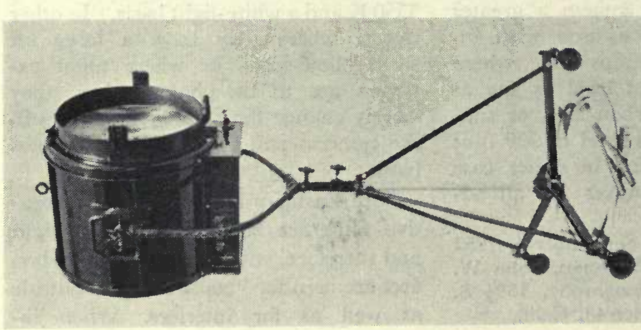

Fig. 1. MR Type 416 "TENER" 10-kw incandescent lamp.

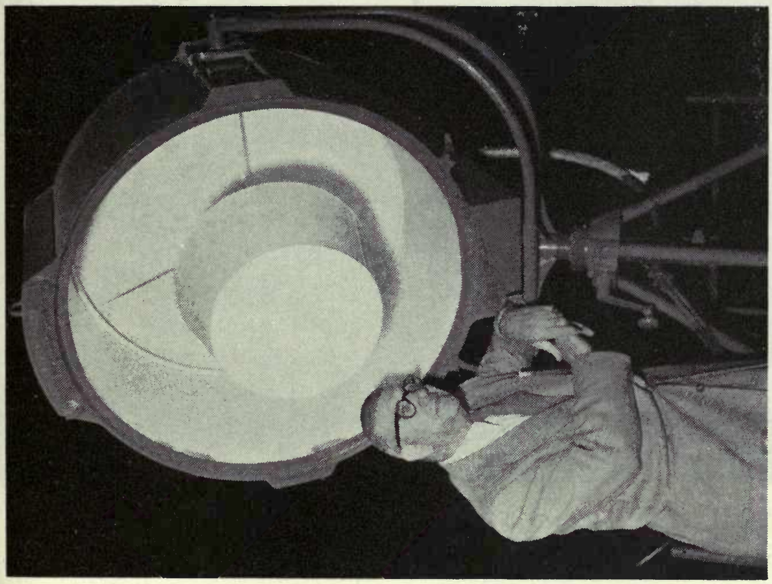

Fig. 3. Reflected light unit designed by Metro-Goldwyn-Mayer Studios.

Fig. 4. Reflected light unit designed by Columbia Studios.

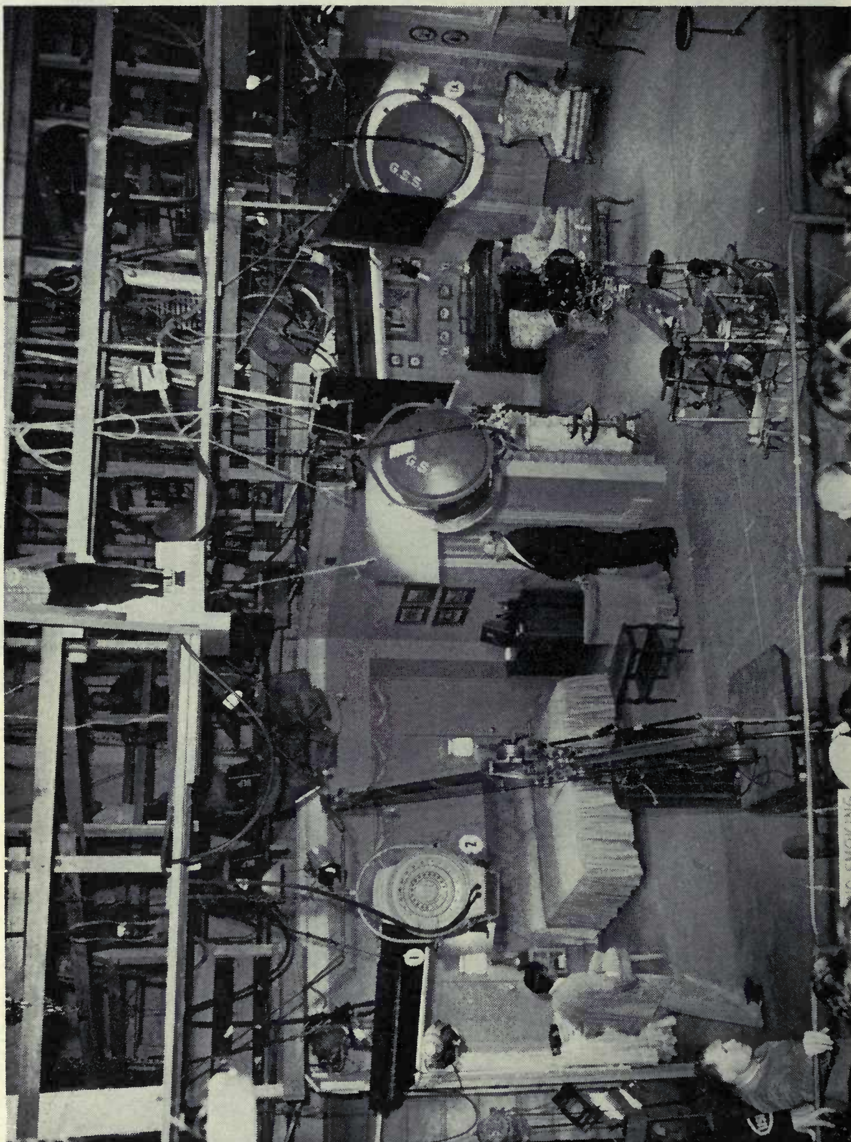

Fig. 5. Set used in Desilu Productions "I Love Lucy."

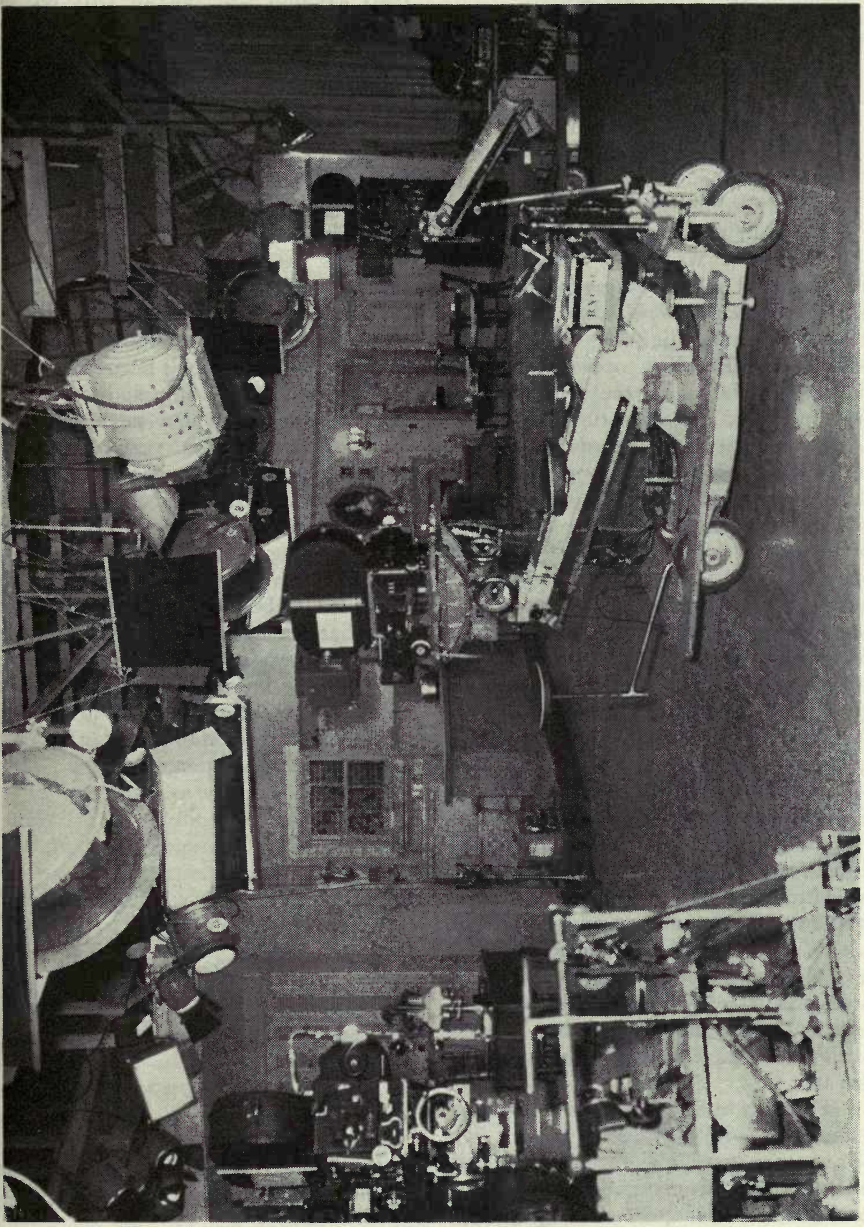

Fig. 6. Set used in Desilu Productions "I Love Lucy."

candescent lamps are used they are equipped with whiterlite filters.

The Paramount Studio's engineering department has developed a remote-control lighting system for use with incandescent lamps (Fig. 2).[3] With this system lightweight units, mounted in various places, may be moved at almost any angle, or the focus changed by remote control from a master station. The system was designed for use on a circus picture where the lamps had to be mounted on the tent poles; however, it is being adjusted with the thought of bringing studio lighting to an automatically controlled operation insofar as is possible. At the time of this writing only the one studio has built any of these motor-drive remote-controlled units.

Several studios have rediscovered the desirable qualities of diffuse lighting of the "north sky light" type for certain applications.[4] It is indicated for general fill-light, for supplementing more directional light on close shots, and overhead on foliage where its diffuse distribution creates a uniformity of illumination as contrasted to the heavier shadow effects produced by the Fresnel-lens type units. For the same reason it is not suitable for shadow effects.

While most of the studios have produced one or more of these "reflected-light" units, Figs. 3 and 4 illustrate types produced at the M-G-M and Columbia studios. These units are lightweight, are easily handled and rigged, are of a simple cone-and-drum shape with interior surfaces coated with flame retardent white paint which has not discolored under temperatures encountered in use.

They are fitted with either one or two bulbs from 750-w to 5-kw in size. At present the housing diameters range from 24 to 60 in., but experimental models of other sizes and shapes are being made.

Figures 5 and 6 illustrate sets used on the Desilu Productions of "I Love Lucy" which is photographed for television. This work is of particular interest because Karl Freund, the veteran Director of Photography who is in charge of photography of this show, has utilized his wide knowledge of motion picture studio lighting practice to produce "plane-lighting" and modelling effects. Many people have indicated that the use of multiple cameras and restricted economies would necessitate very flat lighting but Freund has shown that the judicious use of directional light is not only possible, but is highly desirable.[5]

In spite of the trend toward economy and simplicity of production a number of epic pictures have been made in which production values have been stressed with spectacular sets and lighting techniques. The year 1952 will probably be one where the more or less mechanical, production-line type of lighting will compete with the daring effect lighting to determine if the latter has the draw at the boxoffice which many feel to be the case. One element feels that the audiences do not know the difference between the two and because they do not know the difference, they will not feel the difference; the other element believes that spectacular lighting makes spectacular pictures.

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3. Arthur Rowan, "Set lighting by remote control," *Am. Cinemat., 32:* 444, Nov. 1951.
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5. Karl Freund, "Shooting live television shows on film," *SMPTE 72d Convention Program*, Oct. 7, 1952.

Film Dimensions Committee Report

By E. K. CARVER, Committee Chairman

THE REPORT that follows is much longer than that which the Film Dimensions Committee ordinarily has given. One reason is that it leads up to a discussion of progress toward international standards, as information on this matter has not been widespread through the Society's ordinary channels of communication. Another reason for a lengthy report is that we wish to discuss a situation concerning 16mm film, a field wherein so many people are engaged that they seldom get together in the manner that happens with those who use 35mm film. Accordingly, the committee has sent out several circular letters and desires to make a relatively long public report in an effort to reach everyone that may be interested.

A questionnaire was sent out in March, 1952, to some thirty manufacturers of 16mm film equipment, and the results have been studied. It appears from the replies to the questionnaire that we have not sufficiently emphasized the fact that the proposed change in standard dimensions will not make the present film narrower in width than the film formerly used in cameras or other equipment.

You will remember that the standards are written to describe the film "immediately after cutting and perforating." Although it was very clear in the minds of those who wrote the early standards that these standards referred to widths at the time of slitting, nevertheless there has been the tendency among equipment manufacturers to interpret them to mean the maximum and minimum widths of film that would ever be encountered under any circumstances. The manufacturers of equipment soon learned by experience that film would often be found considerably narrower than the standards. This fact was properly interpreted to be due to the shrinkage of the film. Whenever equipment manufacturers found film to be wider than the standards, they assumed that the film was improperly slit. They did not fully realize that film swells at high humidity and that film, even though properly slit, might swell under high humidity conditions so that its width would be greater than standard.

One reason why this swelling effect was not better known was because of the rapidity of shrinkage which occurred with the old type of high-shrink film. As soon as the package was opened (or even before this in case it was not adequately, hermetically sealed in a metal container) the film started to lose residual solvents and to shrink. This loss of solvents was more rapid at high humidities. Under most circumstances, therefore, the increase in width due to absorption of moisture from the air was more than counterbalanced by the decrease in width caused by loss of solvents to the air. For this reason it was rarely found in practice that film would be

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Presented on October 8, 1952, at the Society's Convention at Washington, D.C., by Dr. E. K. Carver, Kodak Park, Eastman Kodak Co., Rochester 4, N.Y.

wider than the original slit width and, therefore, manufacturers of equipment began to consider that the standards represented the maximum that they would ever encounter. There was a tendency, therefore, to construct film gates and other equipment so that they would pass film with a width of 0.630 in. (16.0 mm) but of no greater width. They felt that any film which exceeded this width must be nonstandard film.

During the past ten or fifteen years film manufacturers have found means to improve the shrinkage characteristics of film and can be expected to make further improvements. Severe conditions which might cause the older type of film to shrink about 1% would cause the newer type of film to shrink only 0.2 to 0.4%. The present film often reaches the camera with no shrinkage whatever. There is not much difference, however, between the amount of swell due to absorption of moisture that occurs with the newer type of film and that which formerly occurred with the older type of film. It thus has become much more common to find the newer type of film wider than standard. Since much of the equipment has been constructed so as not to accept film with a width appreciably greater than 0.630 in., complaints have arisen that the film was slit too wide.

These complaints forced the film manufacturers to change the setting of their slitting knives from about the middle of the standard tolerances down to a point near the narrowest tolerances allowed. Accidental variations in slitting meant that some of the film was slit narrower than the allowed tolerances but no complaints were ever received for that reason. Complaints were still received, however, on film which appeared to be too wide at high humidities. The slitting knives were set still closer to the bottom tolerance. This practically eliminated complaints from film which was too wide but did not introduce any complaints or any difficulties from film which was too narrow. This was true even though a large fraction of the film fell below the "standard" width.

An investigation was undertaken to find out what the widths have formerly been at the time the film was actually used. Statistical studies were made on many samples of film purchased on the open market and of film at the end of its useful life. Measurements were also made in 16mm film exchanges of the regular, professional distribution systems. The various measurements showed clearly that the newer type film even with a reduced slitting width typically would reach the customer with a greater width than old type film. However, the width was not great enough so that one could expect any more trouble at high humidities than have been previously encountered.

The present attempt to change the standard for slitting 16mm film, therefore, is merely an attempt to recognize in a formal manner the changes which the film manufacturers have been forced to make in order to avoid complaints and to give the customer film as near the old width as possible. We call this an effort to maintain the "status quo," which is what the ultimate user often needs.

The Film Dimensions Committee is anxious to make sure that all of the equipment manufacturers thoroughly understand this problem. If these manufacturers were to misinterpret the new standard and reduce the dimension of film gates, then we would be in serious trouble. Complaints of film jamming would increase. Pressure would be put on the manufacturers of film to reduce the width of their film. Competition would force some of them to do so, and then there would be pressure put on the standardizing bodies to reduce the standard width again to conform to the width actually in use. One change would follow another, leading to chaos.

Three methods have been proposed to revise the standard to take care of the above problem. One of them was

simply to change the slitting dimensions, i.e., the dimension A in the Standard, from 0.629 in. ± .001 to 0.628 in. ± .001. Objections were raised to this method of changing the standard be cause it was felt that many people would consider that this meant a true reduction in width of film *as it is used* and would, therefore, reduce the width of the projector gates, camera gates, printer gates, etc., with the results described above.

In order to avoid this difficulty, it was proposed that the Standard for dimension A be written 0.6285 in. ± .0015. This way of writing the dimension would lay claim to the greatest width of the previous standard, namely, 0.630 in., and yet would permit film manufacturers to reduce their slitting width as much as required so that their low-shrink film would not exceed the width of the high-shrink film as previously manufactured. This idea was rejected because some members of the Committee felt that it would make it appear as if the change might be intended to permit less accuracy in slitting width than heretofore.

For the above reasons the Film Dimensions Committee finally agreed to recommend two standards. The old standard was to be kept the same as previously except that an asterisk was to be inserted above dimension A referring to the statement "For low-shrink film dimension A should be 0.628 in. ± .001 and dimension E, 0.0355 in." A definition for low-shrink film was included in the standard. The above method appeared to our Committee to take care of the difficulty in a fairly practical way, and this is the standard that is being recommended to ASA.

On the 9th and 10th of June at a meeting of Technical Committee No. 36 (Cinematography) of the International Standards Organization (ISO) this matter was further discussed. The three propositions as outlined above were placed before the Committee. The members of the Committee were unanimous in agreeing that some actual change in slitting should be adopted. The British delegates were insistent that their standards body would never accept different standards for high-shrink and low-shrink film and that they could not accept the increase in tolerance. The only one of the three proposals which they would accept was the reduction in the standard as outlined in the first of the above propositions with an additional statement somewhat as follows:

"Experience shows that it is common for film to expand when exposed to high relative humidity. Allowance should be made for this factor in equipment design and in no case should the equipment design fail to accommodate a film width of 0.630 in., 16.00 mm."

Rather than see the matter deadlocked, the American group as well as the French and German groups agreed to this modification. Most of us felt that all three proposals were identical in actual content and that any one of them would be satisfactory as an International Standard although we still preferred our own choice for the American Standards.

The actual standards covered by the work of the Committee are: PH22.5, 16mm Double Perforation; PH22.12, 16mm Single Perforation; and PH22.93, 35mm Low-shrink Film. These have been submitted by this Committee to the Standards Committee of the Society. It might be mentioned that the standards for 35mm low-shrink film intended to be used as camera raw stock do not call for a narrowing of the width, nor for other changes that seem quite logical from the point of view of shrinkage alone. The reason for this is that no changes have been made, however logical they may seem, without consulting the people in the trade who are using the film every day. This policy of considering the needs of the user is very desirable in simplifying the procedures and in preventing what might possibly be unnecessary or undesirable changes

Optics Committee Report

By RUDOLF KINGSLAKE, Committee Chairman

THE COMMITTEE has completed its study of the Photometric Calibration of Lens Apertures (published Oct. 1952 for 6-month trial and comment), the final report being now in the hands of the Standards Committee for further action.

American Standard Z22.53-1946, "Method of Determining the Resolving Power of 16mm Motion Picture Projector Lenses," was submitted to the Committee for revision. Three small changes in wording were made which, however, do not affect the fundamental procedure in any way. This Standard has been approved by the Standards Committee for reissue and is currently being reviewed by ASA Sectional Committee PH22.

The next project to be undertaken by the Optics Committee is an attempt to standardize the physical dimensions of motion picture projection lenses. Tentative drawings have been issued showing the proposed outline boundaries between projector and lens, covering two sizes of 16mm lenses and two (or three) sizes of 8mm lenses. Copies have been sent to all known manufacturers of 8mm and 16mm lenses and projectors, and to members of the 16mm and 8mm Motion Pictures Committee, in the hope that a set of dimensions will be reached which will be acceptable to the whole industry.

A report dated August 18, 1952, prepared by Committee Chairman Rudolf Kingslake, Hawk-Eye Works, Eastman Kodak Co., Rochester 4, N.Y., for presentation on October 7, 1952, at the Society's Convention at Washington, D.C.

American Standards—

PH22.83-1952, PH22.38-1952 and Z22.33-1941

In October 1952, the American Standards Association approved one new standard, approved revision of a second standard and withdrawal of a third.

The new standard, PH22.83-1952, Edge Numbering 16mm Motion Picture Film, was published for trial and comment in the January 1951 *Journal.*

Since the change in PH22.38-1952 (formerly 22.38-1944) was so minor, consisting merely of the addition of a note, it was not considered necessary to publish the proposed revision for a trial period. The above two standards are the product of the 16mm and 8mm Motion Pictures Committee and are published on the following pages.

Approval has been withdrawn from the ASA Recommended Practice, Z22.33-1941, Nomenclature for Electrical Filters. This recommended practice was initiated by the Motion Picture Research Council as an outgrowth of some work on theater equipment. It was thought at the time that this method of designating electrical filters would be helpful in the motion picture field. It was useful for a while but has not been so for some time; therefore the SMPTE Sound Committee with the approval of the MPRC initiated withdrawal action about a year ago.—*H. K.*

Correction—

PH22.80-1950 and PH22.81-1950

An error has recently been discovered in two American Standards, Scanning Beam Uniformity Test Film for 16-Millimeter Motion Picture Sound Reproducers (Laboratory Type), PH22.80-1950 and (Service Type), PH22.81-1950, approved in June 1950 and published in the July 1950 *Journal.* The sound track width was given as 0.070 inch instead of 0.072 inch.

These standards are now being reprinted by ASA and republished here on pages 430 and 431.

American Standard

Edge-Numbering 16-Millimeter Motion Picture Film

ASA
Reg. U. S. Pat. Off.

PH22.83-1952

*UDC 778.5

1. Purpose

1.1 The purpose of this standard is to establish a uniform practice with respect to the interval between edge numbers when they are latent-image printed on 16-mm raw stock film. It is not intended to imply that all 16-mm film should be edge-numbered.

2. Edge-Numbering Distance

2.1 The distance between consecutive numbers shall be 40 frames. Thus, the numbers will indicate film footage, subject to a small correction for shrinkage of the film.

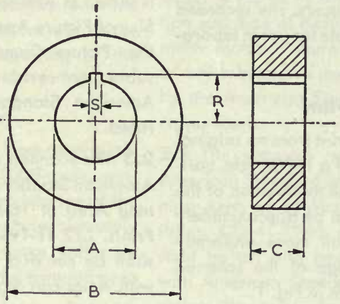
Approved October 8, 1952, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

American Standard

Raw Stock Cores for 16-Millimeter Motion Picture Film

ASA
Reg. U. S. Pat. Off.
PH22.38-1952
Revision of
Z22.38-1944
*UDC 778.5



	Millimeters	Inches
A	25.90 ± 0.20	1.020 ± 0.008
B	50.00 ± 0.25	1.968 ± 0.010
C	15.50 ± 0.50	0.610 ± 0.020
	Recommended Practice	
R	16.70 ± 0.30	0.657 ± 0.012
S	4.00 ± 0.20	0.157 ± 0.008

Bore A to fit freely to hub 25.40 ± 0.1 mm or 1.000 ± 0.004-inch diameter.

It is permissible to reduce the cross-sectional area and to provide a slot in the periphery to facilitate starting the film on the core, so long as these details do not interfere with the stated dimensions. Except for the slot and keyway, the periphery and bore should present smooth, unbroken surfaces.

Approved October 8, 1952, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

American Standard

Scanning-Beam Uniformity Test Film for 16-Millimeter Motion Picture Sound Reproducers (Laboratory Type)

ASA
Reg. U. S. Pat. Off.
Z22.80-1950

*UDC 778.534.4

1. Scope and Purpose

1.1 This standard describes a film which may be used for determining the uniformity of scanning-beam illumination in 16-mm motion picture sound reproducers. The recorded sound track shall be suitable for use in laboratories and factories.

2. Test Film

2.1 The film shall be a print from an original negative. It shall consist of a 1000-cycle, variable-area recording at full modulation of the 0.005-inch width and shall be approximately sinusoidal. The track shall move uniformly 0.067 inch from one edge of the scanned area to the other as shown in Fig. 1.

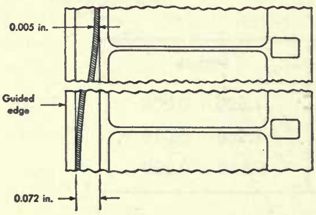


Fig. 1

2.2 The position of the sound track relative to the ends of the light beam at any instant shall be shown by a diagram appearing in the picture area, the size and location of which is shown in American Standard Location and Size of Picture Aperture of 16-Millimeter Motion Picture Cameras, Z22.7-1950, or any subsequent revision thereof approved by the American Standards Association, Incorporated.

2.3 The scanned area shall comply with the American Standard Sound Records and Scanning Area of 16-Mm Sound Motion Picture Prints, Z22.41-1946, and the film stock used shall be cut and perforated in accordance with American Standard Cutting and Perforating Dimensions for 16-Mm Sound Motion Picture Negative and Positive Raw Stock, Z22.12-1947, or any subsequent revisions thereof approved by the American Standards Association, Incorporated.

2.4 The length of this film shall be approximately 34 feet.

NOTE: A test film in accordance with this standard is available from the Motion Picture Research Council or the Society of Motion Picture and Television Engineers.

Appendix

(This Appendix is not a part of this American Standard.)

Before using the above test film it is recommended that correct placement of the scanning beam be determined by means of buzz-track test film as specified in American Standard Specification for Buzz-Track Test Film for 16-Mm Motion Picture Sound Reproducers, Z22.57-1947, or any subsequent revision thereof approved by the American Standards Association, Incorporated.

The uniformity of scanning beam illumination may be measured by means of a db meter connected to the output of the sound projector amplifier. The illumination of the scanning beam should be adjusted according to the instructions furnished by the manufacturer and the variation of the output as registered on the db meter should be observed. The illumination is considered satisfactorily uniform when the output reading as measured by the meter is within ±1½ db across the entire scanning slit.

Approved June 12, 1950, by the American Standards Association, Incorporated

Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

American Standard

Scanning-Beam Uniformity Test Film for 16-Millimeter Motion Picture Sound Reproducers (Service Type)

ASA
Reg. U. S. Pat. Off.
Z22.81-1950

*UDC 778.534.4

1. Scope and Purpose

1.1 This standard describes a film which may be used for determining the uniformity of scanning-beam illumination in 16-mm motion picture sound reproducers. The recorded sound track shall be suitable for use in the routine maintenance and servicing of the equipment.

2. Test Film

2.1 The film shall be a print from an original negative. It shall consist of a 1000-cycle, variable-area recording at full modulation of the 0.005-inch width and shall be approximately sinusoidal. The track shall move uniformly 0.067 inch from one edge of the scanned area to the other as shown in Fig. 1.

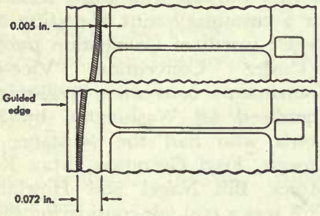


Fig. 1

2.2 The position of the sound track relative to the ends of the light beam at any instant shall be shown by a diagram appearing in the picture area, the size and location of which is shown in American Standard Location and Size of Picture Aperture of 16-Millimeter Motion Picture Cameras, Z22.7-1950, or any subsequent revision thereof approved by the American Standards Association, Incorporated.

2.3 The scanned area shall comply with American Standard Sound Records and Scanning Area of 16-Mm Sound Motion Picture Prints, Z22.41-1946, and the film stock used shall be cut and perforated in accordance with American Standard Cutting and Perforating Dimensions for 16-Mm Sound Motion Picture Negative and Positive Raw Stock, Z22.12-1947, or any subsequent revisions thereof approved by the American Standards Association, Incorporated.

2.4 The length of this film shall be approximately 3½ feet.

NOTE: A test film in accordance with this standard is available from the Motion Picture Research Council or the Society of Motion Picture and Television Engineers.

Appendix

(This Appendix is not a part of this American Standard.)

Before using the above test film it is recommended that correct placement of the scanning beam be determined by means of buzz-track test film as specified in American Standard Specification for Buzz-Track Test Film for 16-Mm Motion Picture Sound Reproducers, Z22.57-1947, or any subsequent revision thereof approved by the American Standards Association, Incorporated.

The uniformity of scanning beam illumination may be measured by means of a db meter connected to the output of the sound projector amplifier. The illumination of the scanning beam should be adjusted according to the instructions furnished by the manufacturer and the variation of the output as registered on the db meter should be observed. The illumination is considered satisfactorily uniform when the output reading as measured by the meter is within ±1½ db across the entire scanning slit.

Approved June 12, 1950, by the American Standards Association, Incorporated

Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

72d Convention, October 6-10

This was a very large and successful convention. We have not developed a whole schedule of comparative statistics for recent conventions and we doubt the prospects of pay dirt in such a vein, for each convention has possibilities and successes peculiar to itself. Such a large and successful convention was nicely fitting as the last convention under Bill Kunzmann, retiring Convention Vice-President. Joe Aiken, as Program Chairman and Local Arrangements Chairman, made the most of the Society's going organization and momentum to build a papers program and he organized the multitude of local arrangements for responsible help by the many capable people in Washington who contributed very generously to the Convention.

A particularly identifiable aspect of the Convention was the seven sessions which comprised the International Symposiums on High-Speed Photography which John Waddell began to promote and develop about a year and a half ago. The success and the breadth of the Symposium were almost entirely the result of John Waddell's work, with associates on the High-Speed Photography Committee coming through with papers and with Joe Aiken anxiously watching and finally arranging the program and meeting facilities for the roster of papers as it rolled up to an unprecedented volume.

Mrs. Nathan D. Golden and Mrs. Joseph E. Aiken, cohostesses for the Ladies' Program, prepared a unique program which brought out 240 ladies for events which included a tea and reception by Mrs. Truman at the White House, the Society's 72d Semiannual Cocktail Hour, Banquet and Dance, a luncheon at the Columbia Country Club, an evening at the Academia of the Motion Picture Association of America, and a tea at the Greek Embassy.

Special arrangements were made by Max Beard for about 130 visitors to attend the session on Thursday Afternoon at the Naval Ordnance Laboratory, White Oak, Md. SMPTE members were welcomed by R. D. Bennett, Technical Director of the Laboratory, who explained the Laboratory's place in the defense program. The Signal Corps Mobile Television System brought the audience a view of certain outlying areas by microwave relay and television receivers. Shock waves in the supersonic wind tunnel were demonstrated.

Hotel and transportation arrangements were locally under Henry Fisher who made arrangements especially helpful for visitors from overseas and also facilitated the extensive program arranged for the ladies. Gerald J. Badgley was active in membership promotion along with Ray Gallo, Chairman of the Society's Membership Committee. Jim Moses gave a welcome assist as a Washington member to Len Bidwell who came from Camden for a customary stint of getting out a big week's worth of Convention publicity.

Under Convention Vice-President Kunzmann, convention registration was organized for Washington by Keith B. Lewis who had the assistance of Phil Cowett, Fred Gerretson, Max Kerr, Jim Moses, Bill Nagel and Howland Pike. This was a real job considering that, along with the tabulation of registration which follows, also to be dispensed were tickets for two luncheons, the banquet, the bus trip to the Naval Ordnance Laboratory, and theater passes and information. This was the way registration for the technical program went:

	Weekly	*Daily*	*Total*
Monday	241	35	276
Tuesday	58	85	143
Wednesday	33	165	198
Thursday	—	129	129
Friday	—	114	114
Total	332	528	860

Projection service for the sessions was organized by Carl Markwith with assistance by William Hecht, Wilson E. Gill, Ralph Grimes, William Youngs and Glen Ornstine. They supplied 16mm and 35mm

equipment for the technical sessions and also met the demands of five pairs of concurrent sessions. Public address and recording of discussion — of which there was a good deal — was under the direction of Jack Greenfield who had the assistance of Robert Dickinson, Richard Simpson, Mike Loria, and Ed Moore who was most effective in stepping into a late schedule for recording some high-speed photography papers, with equipment supplied by Wilson E. Gill.

Further refinements in the Society's public address and recording equipment may be forthcoming. Editorial Vice-President-elect Norwood Simmons has appointed the following committee to study the equipment: George Lewin as Chairman, Edwin A. Dickinson, Jack Greenfield and Fred Whitney.

Motion pictures for the opening of sessions were garnered and made into a coordinated film program by John V. Waller who was assisted by John E. Horton, Jack McCullough and Emerson Yorke. The roster included:

Jet Test, 16-B&W, Air Force

Timber & Totem Poles, 16-color, U.S. Dept. of Agriculture

This Theatre & You, 16-B&W, Motion Picture Assn.

Operation Greenhouse, 16-color, Atomic Energy Com.

School for Dogs, 35-B&W, RKO

Screen Actor, 16-B&W, Motion Picture Assn.

Shining Rails, 16-color, Gen. Electric

Gambling, 16-B&W, Navy

Small Town Editor, 16-B&W, State Dept.

Shoemaker & The Hatter, 16-color, Mutual Security Agcy.

Costume Designer, 16-B&W, Motion Picture Assn.

Representative Instructional Films, 16mm Maint., Various

Arch Against The Sky, 16-B&W, Gt. Lakes Steel Corp.

Unlocking The Atom, 16-B&W, Universal

Let's Go To The Movies, 16-B&W, Motion Picture Assn.

Tanglewood, 16-B&W, State Dept.

Screen Writer, 16-B&W, Motion Picture Assn.

There were more persons than usual from overseas, many of them coming for the International Symposium on High-Speed Photography (see photo). A highlight of the Symposium was the High-Speed Photography Luncheon on Wednesday noon when A. C. Keller spoke on "The Economics of High-Speed Photography" which is published elsewhere in this *Journal*. John Waddell was master of ceremonies to welcome an overflow crowd in the luncheon hall. There were several of the Society's officers and Governors at the High-Speed Luncheon. John Frayne, Editorial Vice-President, spoke briefly about the accomplishments of the High-Speed Photography Committee and assured the High-Speed photographers of the Society's continuous policy to help in every way possible, believing that the interests and activities of high-speed will be served well within the Society's organizational structure which permits integrated activity of varying but related interests and which at the same time brings the benefits of mutually sharing in facilities, overhead and man-hour costs.

It was of some interest to note not only at the High-Speed Luncheon but also at the high-speed paper sessions that a sizable fraction of those attending had registered for the entire week and also that quite a few persons shuttled between high-speed and the concurrent session in order to hear particular papers. This may or may not be an indication of greater diversification of high-speed people's interest, to include phases of laboratory practice, optics or sound.

The highest attendance at a session was 247 on Tuesday afternoon for Karl Freund's paper "Shooting Live Television Shows on Film." It was read by John Boyle in the absence of the author who is currently on a rigid four-days-a-week Hollywood television schedule. The paper was tainted with entertainment possibilities by showing on a sizable screen a film of *I Love Lucy* which demonstrated the cameraman's problem.

The only other sessions to draw over 200 were two of the seven sessions of the International Symposium on High-Speed Photography. During the high-speed sessions there was some filing in and out for particular papers but, during the first two

Five of the world's foremost specialists on high-speed photography discuss program for largest international symposium on the subject at the 72d Semiannual Convention. Left to right: Dr. Hubert Schardin of Weil Am Rhein, Baden, Germany, Director of the French Ordnance Laboratory at St. Louis, France, and world authority on ballistics photography; Dr. Carl Jennergren, of the research staff of the Swedish Ordnance Laboratory at Stockholm; W. D. Chesterman, of the Royal Naval Scientific Service in London, author of the first English text on high-speed photography; Gilbert Ruellan, Managing Director of the Andre Debrie Establishment, French manufacturers of motion picture equipment; and Major P. Naslin, of the research staff of the French Ordnance Laboratory of Vincennes, co-author of the world's first text on high-speed photography, published in 1950.

days of high-speed, attendance held to an average of 150. By Friday apparently even the high-speed photographers' fibers and capacities were taxed, for then attendance averaged 80.

The Monday evening television session and the Thursday evening 16mm maintenance sessions held the rapt attention of about 80 throughout. Other sessions not previously mentioned ranged from 125 to 175.

There were fourteen committee meetings held during the Convention, many of them lasting for several hours. Reports of these appear in the Engineering Activities column in this *Journal.*

The Luncheon and Banquet were organized by Nate Golden who put them on with a strict schedule. The awards presented at the Banquet will be described in the December *Journal.* Nate Golden arranged for speakers from the three service branches. Their remarks before the Get-Together Luncheon were impressive and warmly received. The speeches are abstracted below. One of Joe Aiken's special plans for this Convention was to feature the Signal Corps Mobile Television Unit. This and other television plans were under Ralph N. Harmon and Col. C. S. Stodter. W. P. Dutton was most helpful in the planning but unfortunately was ill at Convention time. The Get-Together Luncheon program was picked up by the Signal Corps Mobile Unit and sent to the Pentagon. The program included speeches abstracted as follows:

Ranking photographic authorities of the Army, Navy and Air Force confer with Peter Mole (second from left), President of the Society of Motion Picture and Television Engineers, on luncheon program opening the Society's 72d Semiannual Convention at the Hotel Statler, Washington, D.C. The military experts, who were guest speakers at the luncheon, are (left to right) Major General George I. Back, Chief Signal Officer of the Army; Brig. Gen. Brooke E. Allen, Chief of Staff of the Military Air Transport Service and, until recently, Commanding General of the Air Photographic and Charting Service of the Air Force; and Capt. A. D. Fraser Chief of Naval Photography in the Office of the Chief of Naval Operations.

Get-Together Luncheon Remarks by President Mole

A short time ago I had occasion to review the history of engineering in the motion picture industry, and I was reminded repeatedly of the mature judgment and wisdom that our predecessors in this Society had contributed to the progress of motion picture technology. They played an important part in the development of sound and color motion pictures and standardization, all of which are commonplace today.

We are on the threshold of another era of progress. I am sure we will all agree that the movies and television can not only live together but can supplement and strengthen one another. The record of cooperative engineering within our Society, which extends across both fields, is already an impressive one, and through such efforts we have sounded a note of profound encouragement for both the economic and the technical future of the field in which most of us make our daily living.

This week here in Washington, some of our most distinguished members will be discussing questions of serious importance to the future of theater television. Last week a significant event occurred when Cinerama, a development many years in the making, was first demonstrated to the public in New York. The week before, large-screen theater television enabled thousands from coast to coast to witness the championship bout between Rocky Marciano and Jersey Joe Walcott. More people saw the telecast in movie theaters than were actually in attendance at the fight. Now, none of us can predict in exactly what direction theater television will develop. Nor can we foretell the future of Cinerama, or that of the several new systems of motion picture color.

But one thing is *certain* — these technical developments and the excitement they have created, within and outside our field of professional engineering, are together the most encouraging symptoms to appear in the past ten years. They are evidence of a new, widespread, and healthy interest in the technical future of both motion pictures and television. I sincerely hope they will spark a chain reaction that will eventually stimulate each one of us, working together in this Society, to accomplishments greater than any we have yet attained.

Excerpts From Address by Gen. George I. Back

It is a distinct pleasure for me to join with you at the opening session of your 72nd Semiannual Convention and to be given the opportunity of presenting some of my thoughts regarding motion pictures and television within the Army.

Broadly speaking, the Signal Corps, in keeping with its responsibility for providing an integrated communications system for the Army, must be prepared to transmit information (or what we call intelligence), whatever its form may be. This intelligence may be transmitted as the spoken word, the written message, or in the form of a pictorial representation. It may be directed to a single person or to several addressees at different places throughout the world. It may also be intended for mass distribution to thousands.

In the process of transmission, intelligence may take many and varied forms as it is transformed through electronic, mechanical magnetic or photographic processes. But whatever the processes employed, they must be designed to provide a thoroughly integrated, but flexible, system which will deliver the message accurately and rapidly.

The motion picture has served the Army well through two world wars. The sound motion picture is doing the same important job in the Korean conflict, as a medium for training our forces, as a means for promptly acquainting the American public with our operations in combat, and finally as a means of pictorially documenting military history as it is written. Of possible interest is the fact that seventy million man-hours of military training are accomplished annually by the Army through the use of training films. Furthermore, many of these films are extensively used by our allies after the script has been rescored in the appropriate language, thus creating a unity of military thinking and a better understanding of mutual security problems. Similarly, in the field of research and development of military equipment, methods and tactics, the motion picture has become an irreplaceable tool, since it provides a means for repeated analytical study of critical phases of a given operation, whether it be a military maneuver or the testing of such weapons as the atomic bomb or the guided missile.

While military applications of the sound film continue to multiply, television has become available as another medium for the transmission of sound and pictures, a medium which offers tremendous possibilities with its potential of speed and accuracy. Although the full military possibilities of television have not yet been determined, we have for some time been engaged in exploring its manifold applications. In this work we have been guided by our past experiences in the pictorial communication field. Many possible applications for military television suggest themselves. To mention but a few:

Distant tactical observation of military positions and actions from the ground and air.

Bringing distant or relatively inaccessible subjects into many training classrooms simultaneously.

The tactical briefing of widely separated commanders.

Guidance and control of land vehicles and light aircraft.

Close-up observation of the action and effect of our weapons.

Mass dissemination of important information in pictorial form to reserve and civilian components of the armed services and to the public at large.

These are only a few of the suggested fields of employment. I believe, however, that they indicate the trend of military thinking toward full utilization of this new method of communication.

Incidentally, the Signal Corps is pleased to be able to bring to this convention the Mobile Television System which is being used in our fundamental explorations of television's possible military applications. This equipment embodies much of the engineering skill which you engineers have contributed to the development of the television medium and emphasizes the spirit of scientific cooperation that exists between your industry and the Signal Corps. Needless to say, we in the Army are grateful to you for the splendid assistance we are receiving from you.

I should like to point out here that the Army has recognized the need for complementary development and utilization of television and sound motion pictures in order to obtain the maximum effectiveness of both media, just as you engineers have recognized that the two are complementary and compatible, rather than exclusively competitive. Only television can reproduce an event at a distant point instantly, but only motion pictures can record and retain the image of that event. By combining the electronic immediacy of television with the photographic retentiveness of the motion picture, we can have available to us the maximum facility possible in pictorial communication. For this reason, the Army has placed the responsibility for development of both media in the hands of the Signal Corps, thus assuring full coordination in their development.

In closing, I should like to appeal to you for continued assistance and cooperation in the research and development field in both sound motion pictures and television. This is essential if we are to provide our combat forces with the best that industry can produce. By that I mean techniques and equipment which will insure complete reliability under field operating conditions, optimum performance characteristics consistent with the state of the art, and reasonable cost under conditions of mass production. Any lesser goal will not be good enough.

Excerpts From Address by Gen. Brooke E. Allen

. . . . The Air Force is privileged to have both in uniform and as civilians members of your distinguished Society. The closer our association with you the easier it will be to accomplish our job for the Air Force. Be assured that we fully appreciate the accomplishments of the scientists, the engineers and the technicians in your field, and we gladly join ranks with you and propose to do our full share toward the advancement of the art.

When I received my invitation to speak to you, I was in command of the Air Photographic and Charting Service, which constitutes one of the family of operational services under the Military Air Transport Service. Shortly thereafter I was transferred to my present position as Chief of Staff of the Military Air Transport Service.

Since it was my responsibility to establish the Photographic Service, it is close to my heart, and I could not possibly forego a chance to explain its missions and aims to you.

I should like to go back a bit in order to get the record straight. Photography since its inception has been vitally important to the military. Aerial photography began to have meaning when intelligence photographs were laboriously taken from captive balloons in the war between the states. A century ago, an ingenious Frenchman made a map of Paris on the basis of photographs taken from a balloon. Out of that simple beginning grew the science of military photography.

The development of motion picture photography has made it possible to document photographically the live action of the battlefield, on land, on the sea and in the air. The vital military importance of such a photographic record is obvious, just as every football coach insists on a motion picture record of Saturday's game for Monday's critique.

Under the Unification Act of 1947, the Department of the Air Force was given complete responsibility for its own photographic functions. This did not, however, result in the automatic establishment of a satisfactory organization to perform those functions.

Instead, the photographic responsibility became scattered among the major air commands without overall control,

supervision or coordination. This was simply one of the growing pains connected with the establishment of the Air Force as a separate Department along with the Army and the Navy.

It was not strange, therefore, that the outbreak of hostilities in Korea found the Air Force unprepared to meet its photographic requirements in an efficient and organized manner. The Army and the Navy, on the other hand, were well prepared to document their combat activities with photography, so essential for operational purposes. When the Chief of Staff of the Air Force became aware of the situation, he directed the immediate establishment of a photographic service to satisfy the most urgent requirements of the Air Force.

After almost a year of careful study and planning, the scattered but related activities of the Air Force were reorganized under a single command, which was designated the Air Photographic and Charting Service. The principal elements of the Photographic Service are:

The Photographic Documentation Group;

The USAF Photographic Center;

The Mapping and Charting Group; and

The Aeronautical Chart and Information Center.

The units of these activities are of necessity scattered from Korea through Europe, to North Africa and the Middle East. Wherever the global mission of the Air Force requires its operation, there also you will find units of the Air Photographic and Charting Service.

I should like to emphasize that during the year in which the Photographic Service was being organized and firmly established, photography did not stand still. During that first year our Combat Camera Unit in Korea piled up over 300 combat missions and exposed more than 225,000 feet of motion picture film in combat. The Unit ran up an outstanding record of awards and decorations and took their combat losses along with the fighting units.

Today we are happy to fall in step with the pace set by you television engineers. We have brought the field of electronics into a firm position in our organization. Indicative of how we are accomplishing this in the Photographic Service is the fact that the production division has a split title. It is called the Motion Picture and Video Production Division. In this Division we have affected a marriage of these two fields without any of the initial rivalry that ran through industry when the motion picture and the television people first eyed each other warily from opposite sides of the fence.

It was a matter of firm pride to think that I was connected with the creation of a video production unit in the Air Photographic and Charting Service. The mission of this unit is built around the high-speed concept, completely mobile with the latest electronic equipment. This unit is now undergoing the equipping phase prior to an operational shakedown.

It was established on an experimental basis to ascertain as early as practicable the applicability of television to the operational and training mission of the Air Force. Part of their portable equipment is a 16mm rapid processor which was first presented, I believe to the Society at your convention in Chicago in April 1950. As you know, this machine presents a ready-to-project print beginning ninety seconds after initial photography.

As the author of any new work takes great pride in crediting his source material, we do so with a bow of great appreciation to industry and to our elder services — the Army and Navy. Throughout all of our efforts, we have maintained liaison with industry, with the experiments conducted by the universities and colleges throughout the country and the work done by the Navy in its Special Devices Center at Sands Point and, of course, with the Army's "Operation Caravan."

No great degree of imagination is required to see unlimited possibilities in the application of TV to technical, flight and combat crew training, and through kinescope recordings the preparation of training films with celerity and informality hitherto impossible. What we lose in artistry, we gain in speed and volume.

I have given you a rough sketch — yesterday, today and tomorrow — of photography and television in the Air Force. Your meeting here in Washington seems to key note high-speed. In the Air Force we are trying to keep our thinking and our planning in that same key — to keep the pace that you are setting.

In discharging its global mission in photography and television, the Air Force is seeking every means to get information faster and better and to put it to its maximum use in the shortest time. As you television engineers know the television circuit can be the shortest and speediest route from live action to finished film. This is of major importance to us today. As you engineers come up with new methods, new techniques, faster and better ways to accomplish our mission, you can be sure that the Air Force matches your zeal with our own desire. We are proud to serve with you in the search for better ways of getting the job done.

It is a constant but exciting challenge. We are happy to be able to join you in it. As for the future, the course seems clear ahead of us. To coin a phrase, we have now become airborne and over our first and most difficult obstacles. As for the rest, the horizons are unlimited.

Excerpts From Address by Capt. A. D. Frazer

. . . . In the Navy, we use motion pictures extensively and the requirements for the use of television are continually expanding.

Entertainment motion pictures provide probably our greatest morale booster. Every ship and station has movies and I can tell you from personal experience that when the movies do not arrive or they cannot be shown for some reason the boys are very unhappy. We are, of course, dependent on the motion picture industry for these films and are deeply appreciative of the service provided and the technical improvements that have been made to give us better sound and color for the adverse conditions encountered in shipboard screenings.

In our military use of motion pictures, the largest single requirement is in the field of training films. We also use them extensively for test and evaluation of new equipment. This is especially true in the guided missile program where high-speed motion picture photography has become most valuable.

Recording of Naval operations for historical purposes and evaluation is of great importance. There is a growing need for motion pictures in combat briefing.

Boat crews that have to approach a hostile beach during an amphibious operation can learn a great deal from seeing movies of the beach area made previously.

[Capt. Frazer spoke briefly of the Navy's training film program — this was described in detail by Cronenwett and Timmons in the July 1952 *Journal.*]

In the development and test of new equipment, motion pictures have proven to be invaluable. This has been particularly true in the evaluation of equipment that operates faster than the eye can follow or the mind record. A few examples are:

Wind tunnel tests of sonic and transsonic airfoils;

Instrument recordings of tests of new aircraft;

Recording of instrument readings of tele-metered flights of guided missiles;

Determination of explosion;

Phenomena of new types of weapons and explosives and their effect on naval equipment; and

Verification of proper sequence and operation of a series of functions in various mechanical and electrical devices.

Many of these uses will be discussed in detail in later sessions of your Convention.

On our larger ships, and especially in aircraft carriers, we have motion picture camera equipment for recording various aspects of naval operations. These are used for historical recording, and for study to improve the execution of various maneuvers and to detect deficiencies in equipment.

Training in the basic techniques of motion picture photography is given to all students at the Navy's photo school at Pensacola, Florida. A specialized course at the same location is also conducted for a limited number of advanced students.

The motion picture industry in Hollywood very generously operates a comprehensive on-the-job training course for selected personnel. This program has proven to be most beneficial and provides a phase and completeness of instruction that is not possible of attainment in a service school.

In the field of television, the Navy has

been active in development work since before World War II. Television control of drone aircraft was successfully demonstrated and used in the South Pacific by the Navy in 1944. More recently, as reported in the press, it has been used successfully in Korea.

The employment of television for Naval purposes opens many new possibilities. Improvement in the equipment will, however, be necessary. Needed are further reduction in size and weight of camera and transmitting equipment, and considerable improvement in reliability under very adverse operating conditions with substantial increase in reception distance. These requirements sound somewhat contradictory but I am confident that the industry can solve the problems.

Photo recording of television and cathode-ray tube images has been carried out in the Navy for some time. This utilization has progressed to the point where much of the work is done automatically. There is still room for progress, however, in the development of new and more sensitive emulsions and more rapid processing of these emulsions. Results obtained along these lines, to date, have been very gratifying. In the field of group instruction, television has been used experimentally and the Navy Special Devices Center is continuing study of this medium. Test instruction has been quite satisfactory and indicated a good percentage retention of transmitted information. Closed circuit, broadcast, and kinescope methods have been used in this program. The feasibility of using this system for briefing purposes and group instruction within task forces at sea is under development for evaluation.

The uses of television in the testing and examination of devices and equipment for naval employment are almost limitless. Small television cameras can be placed within equipment where it is physically impossible for a human observer to be under such conditions as: limitations of space, atmospheric conditions, high G forces, high temperatures, or severe vibration. There are many more.

The Navy is vitally interested in new developments in the field of television and motion pictures. Their parallel use holds great promise for the future. We look to the Society of Motion Picture and Television Engineers for future developments that will make past successes seem insignificant by comparison.

Engineering Activities

72d Convention Thirteen Engineering Committees held meetings at the 72d Convention in Washington, D.C., October 6–10. This in itself made for lively, efficient meetings. The schedule was tight and required the use of mornings, afternoons and evenings — including the "morning after" the Wednesday night banquet. On several occasions there was hardly time for the chairs to cool as one meeting adjourned and another was called to order. The meetings successfully furthered standards activity and provided opportunities for the exchange of "shop" talk.

Standards activity is at a very high level today. In addition to the development of new standards required by growth and changes in the industry, the Society is in the process of actively reviewing (in accordance with ASA rules) all standards currently over three years old. The highlights of this activity as discussed in the various committee meetings will be presented below and also in the December *Journal*.

Film Dimensions Dr. E. K. Carver, Chairman, was unable to be present and his alternate, Dr. A. C. Robertson, chaired the meeting. The status of active projects was reported as follows:

PH22.1, Alternate Standards for Positive or Negative 35mm Raw Stock Film — This proposal was published for trial in the September 1951 *Journal*, approved by the Standards Committee in July 1952, by ASA Sectional Committee PH22 and SMPTE Board of Governors in October 1952 and is presently before the Photographic Standards Correlating Committee.

The following three standards (two revised standards and a new proposal) were approved by the Film Dimensions Committee and are now being reviewed by the Standards Committee.

PH22.5, Dimensions of 16mm Silent Motion Picture Film,

PH22.12, Dimensions of 16mm Sound Motion Picture Film, and

PH22.93, Dimensions of 35mm Low Shrink Camera Raw Stock Film

The periodic review of standards has brought four standards up for consideration and it was agreed that three should be revised:

Z22.17-1947, 8mm Film Dimensions,
Z22.31-1946, Definition for Safety Film,
Z22.36-1947, 35mm Positive Film Dimensions;

and the fourth reaffirmed:

Z22.37, 1944, 35mm Raw Stock Cores.

Film Projection Practice This committee is similarly reviewing four standards and here it was also agreed that one should be reaffirmed:

Z22.4-1941, 35mm Projection Reels;

and three revised:

Z22.29-1946, Projection Rooms and Lenses,
Z22.35-1947, 35mm Sprockets, and
Z22.58-1947, 35mm Projector Aperture.

In addition several dormant projects, "Projection Room Plans," and "Arc-Lamp Mounting Dimensions," were discussed and plans made to reactivate them. Finally, the desirability of standardizing the Society Leader from both a television and a theater point of view was mentioned and initial action in that direction approved.

Films for Television This committee was largely responsible for the development of the Television Test Film. Much thought was given at this meeting to ways and means of further improving it and changes may be expected in the near future.

Standardization of the Society Leader was discussed at this meeting also. As was mentioned in the May 1951 *Journal*, this leader was developed by the Leader Subcommittee, chaired by Charles Townsend. It was designed to keep the basic features of the Academy Leader required by the theater projectionists while adding useful information required in projecting films for television. The Subcommittee was now asked to revise paragraph 3 of the Release Print Standard, Z22.55-1947, to incorporate use of this new all-purpose leader.

Laboratory Practice Some half dozen standards are being reviewed by this committee but discussion on them was tabled until returns on the letter ballot, issued a few weeks before the meeting, are more complete.

Instead the discussion revolved about two projects which have occupied the committee's attention for some time: (1) Screen Brightness in 16mm Laboratory Review Rooms; and (2) Printer Light Change Cueing. No fundamental differences exist about the latter and agreement was readily reached on a second draft soon to be circulated to the committee. Quite the converse is true of the former. Here there are two schools of thought, one holding that 16mm and 35mm screen brightness should be the same (9–14 ft-L) and the other arguing for a lower value (5–10 ft-L) in 16mm review rooms. The final decision was to issue a second letter ballot, this time setting forth the arguments for both positions and allowing for a choice of either set of values.

Screen Brightness The 16mm review room screen brightness proposal was also discussed here and with similar views expressed. This committee will receive the same letter ballot prepared for the LP Committee.

The Subcommittee on Instruments and Procedures submitted a final report of its findings. This was approved for *Journal* publication with but minor editorial changes.

Wallace Lozier, Chairman, reported on the status of the revision of the Screen Brightness Standard, PH22.39. This has run the gamut of approval within the SMPTE, was published in the May 1952 *Journal* for trial (no adverse comment was received) and is presently being reviewed by ASA Sectional Committee PH22—*Henry Kogel*, Staff Engineer.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 Membership Directory.

Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

Bader, David A., Writer, Journalist, Literary Associates. **Mail:** 147–66 Village Rd., Jamaica 35, N.Y. (A)

Ball, Howard D., Film Projectionist, Kennedy Broadcasting Co. **Mail:** Box 87, La Jolla, Calif. (A)

Del Rosario, Macario T., M/Sgt., U.S. Army, Qtrs. 111-C-1, Governors Island, New York 4, N.Y. (A)

Ellington, Frederick K., Theatre Circuit Maintenance Supervisor, Syndicate Theatres, Inc., Crump Theatre, Columbus, Ind. (A)

Epstein, Sidney, Electronic Engineer, S.O.S. Cinema Supply Co. **Mail:** 111 Tudor Pl., Bronx 52, N.Y. (A)

Hathaway, Henry R., Jr., Officer in Charge of Sound Recording Dept., U.S. Air Force. **Mail:** 1027 Columbia Dr., Bucknell Manor, Alexandria, Va. (A)

Heathcote, Bruce, SRT-TV Studios. **Mail:** 45–36 — 49 St., Woodside 77, N.Y. (S)

Henderson, John E., Projection Room Supervisor, Jefferson Standard Broadcasting Co. **Mail:** Sardis Rd., Charlotte, N.C. (M)

Maloof, Michael B., Jr., Audio Control Engineer, Paramount Television Productions. **Mail:** 1155 N. Heliotrope Dr., Los Angeles 29, Calif. (A)

Minor, M. J., Radio Engineer, Jefferson Standard Broadcasting Co., 508 Wilder Bldg., Charlotte, N.C. (M)

Navon, M., Director, Geva Films, Ltd., 32 Allenby Rd., Tel Aviv, Israel. (A)

Norling, Richard V., Motion Picture Technician, Byron, Inc. **Mail:** 12119 Edgemont St., Silver Spring, Md. (A)

Seitz, Henry J., TV Film Transmission, Columbia Broadcasting System. **Mail:** 89–18 Rutledge Ave., Glendale, L.I., N.Y. (A)

Sykes, Langthorne, Electronic Scientist, U.S. Naval Ordnance Test Station. **Mail:** P.O. Box 455, China Lake, Calif. (A)

Teitelbaum, Ben, Partner, Hollywood Film Co., 5446 Carlton Way, Hollywood 27, Calif. (A)

Teitelbaum, Harry, Partner, Hollywood Film Co., 5446 Carlton Way, Hollywood 27. (A)

Todd, Clayton S., Engineer, Metro-Goldwyn-Mayer Studio. **Mail:** 3354 Mills Ave., La Crescenta, Calif. (A)

Tyo, John H., Audio-Visual Center, Indiana University, Bloomington, Ind. (S)

Wallis, Gilbert, Project Engineer, Land-Air, Inc. **Mail:** 405 Deney La., Alamogordo, N.M. (A)

Zale, Ben, Editor, Industrial Photography, 1114 First Ave., New York 21, N.Y. (A)

CHANGES IN GRADE

Hu, Tsu-Ming, (S) to (A)
Stevenson, Murray H., (A) to (M)
Watermeyer, Erwin, (A) to (M)

DECEASED

D'Andrea, Matthew J., Free-Lance Technician. **Mail:** 18 Hudson Ave., Edgewater, N.J. (M)

Levinson, Nathan, Sound Director, Warner Brothers Pictures, Inc., Burbank, Calif. (F)

Pariseau, S. M., District Manager, Altec Service Corp. **Mail:** 1956 S. Vermont Ave., Los Angeles 7, Calif. (A)

Meetings

Society of Motion Picture and Television Engineers, Central Section Meeting (in conjunction with Society of Photographic Engineers), Dec. 3, Bell & Howell Co., Chicago, Ill.

American Institute of Chemical Engineers, Annual Meeting, Dec. 7–10, Cleveland, Ohio

American Institute of Electrical Engineers (Symposium on The Science of Music and Its Reproduction — 2d Lecture), Dec. 11, Engineering Societies Bldg., New York, N. Y.

American Society of Photogrammetry, Annual Meeting, Jan. 14–16, Shoreham Hotel, Washington, D. C.

American Institute of Electrical Engineers (Symposium on the Science of Music and Its Reproduction — 3d Lecture), Jan. 15, Engineering Societies Bldg., New York, N. Y.

Society of Motion Picture and Television Engineers, Southwest Subsection Meeting, Jan. 16, Dallas, Tex.

American Institute of Electrical Engineers, Winter General Meeting, Jan. 19–23, New York, N. Y.

American Physical Society, Annual Meeting, Jan. 22–24, Cambridge, Mass.
Institute of Radio Engineers Conference and Electronics Show, 5th Annual Southwestern Conference and Show, Feb. 5–7, San Antonio, Tex.
American Institute of Electrical Engineers (Symposium on the Science of Music and Its Reproduction — 4th Lecture), Feb. 20, Engineering Societies Bldg., New York, N. Y.
National Electrical Manufacturers Association, Mar. 9–12, Edgewater Beach Hotel, Chicago, Ill.
Society of Motion Picture and Television Engineers, Southwest Subsection Meeting Mar. 16, Fort Worth, Tex.
Inter-Society Color Council, Annual Meeting, Mar. 18, Hotel Statler, New York, N. Y.
Optical Society of America, Mar. 19–21, Hotel Statler, New York, N.Y.
American Physical Society, Joint Meeting with APS Southeastern Section, Mar. 26–28, Duke University, Durham, N.C.
American Physical Society, Apr. 30–May 2, Washington, D.C.
Acoustical Society of America, May 7–9, Hotel Warwick, Philadelphia, Pa.
Society of Motion Picture and Television Engineers, Southwest Subsection Meeting, May 20, Dallas, Tex.
American Physical Society, June 18–20, Rochester, N.Y.
American Institute of Electrical Engineers, Summer General Meeting, June 29–July 3, Atlantic City, N.J.
Biological Photographic Association, 23d Annual Meeting, Aug. 31–Sept. 3, Hotel Statler, Los Angeles, Calif.
The Royal Photographic Society's Centenary, International Conference on the Science and Applications of Photography, Sept. 19–25, London, England
Theatre Equipment and Supply Manufacturers' Association Convention (in conjunction with Theatre Equipment Dealers' Association and Theatre Owners of America), Oct. 31–Nov. 4, Conrad Hilton Hotel, Chicago, Ill.
Theatre Owners of America, Annual Convention and Trade Show, Nov. 1–5, Chicago, Ill.
National Electrical Manufacturers Association, Nov. 9–12, Haddon Hall Hotel, Atlantic City, N.J.

Employment Service

Positions Wanted

Audio-Visual School of Education Graduate: M.A., Audio-Visual Education, New York University. Sound background in personnel and contact work, attractive, single, personable. Prefer position New York or New Jersey area. Spent 3 years abroad, civilian, Special Services Director. Miss Fredericka Appleby, 810 Broadway, Newark, N.J. HUmboldt 5-4582.

TV Producer-Director: Formerly Chief of Production in Army's first mobile TV system, experience in writing-directing high-speed, low-cost instructional productions; TV producer-director, KRON-TV San Francisco, five shows weekly. Desire connection in educational TV, preferably employing kinescope technique; married; prefer West Coast, but willing to travel; résumé, script samples, pictures of work — on request. Robert Lownsbery, 1116 E. Claremont St., Pasadena 6, Calif.

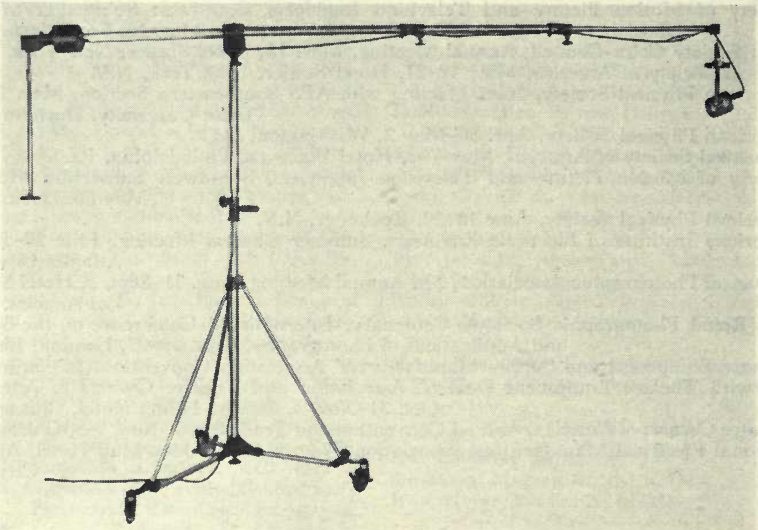
Research, field engineering, manufacturing opportunity for B.S. Electrical Engineering candidate, Jan. 1953; Scholarship student, M.I.T.; studied in Germany, 1945–1950. Languages: German, Polish, Russian and English. Some radio shop experience; also M.I.T. Library and Engineering Dept. Single, no dependents; Military Status, 5A (over 26). Prefer location in East. Joseph Liebermann, 513 Beacon St., Boston, Mass.

Position Available

Wanted: Young engineer, mechanical or electrical deg; with liking for fine machinery and creating it, some experience in mechanical design and some knowledge of optics or electronics; for work on development of new products; applications held in full confidence. Send complete résume to Sherman Fairchild and Assoc., Rm 4628, 30 Rockefeller Plaza, New York, Attn: Mr. Fairbanks.

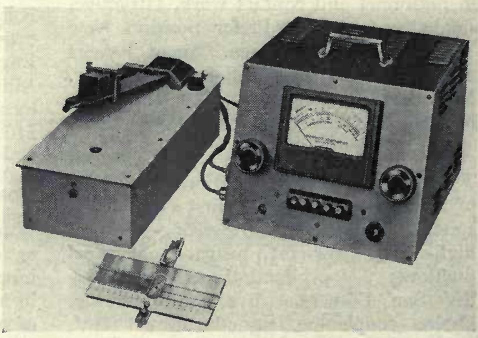
New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.



Portable microphone boom, for studio or location work, has been made of aluminum tubing and bronze castings. It telescopes approximately 7 to 17 ft, has a balance weight at the rear of the boom that is adjustable for extension, and has a remote control allowing 360° rotation of the microphone by a universal angular control from the back. The boom dolly is a two-section telescoping unit with collapsible legs and ball bearing casters, with foot locks. The boom complete with stand collapses for portability and weighs about 100 lb. Further details are available from National Cine Equipment Inc., 209 W. 48 St., New York 19, N.Y.

The Photovolt Densitometer, a product of Photovolt Corp., 95 Madison Ave., New York 16, is a combination of a Model 520-A Multiplier Photometer, a Model 52 light source unit and a special guide attachment for 35mm and 16mm film strips. It is designed to measure color (and black-and-white) densities in very small spots in the image area as well as in ordinary and silver sulfide sound tracks. It is equipped also to read densities on sensitometric tablets.



SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal.*

The Electronic Camera in Film-Making

By NORMAN COLLINS and T. C. MACNAMARA

The paper considers the cinematograph camera and assesses its inherent limitations. The advantages of multiple-camera working are discussed, with special reference to the electronic camera; the recording of an electronic image is shown to be the culminating development. The paper discusses picture quality, contrast range and tonal fidelity, and the objective and subjective evaluation of definition. The reconciliation of the electronic and photographic viewpoints is shown to be possible, and the standards of the motion-picture and television industries are compared. The paper concludes with a survey of the performance requirements of the electronic camera, the mechanics of motion-picture recording of electronic images and factors governing the choice of film stock.

(1) Introduction

Up to the present, the history of film-making has been virtually the history of the cinematograph camera as it was conceived by Friese-Greene and Lumière. Technical progress in design and development has been constant, but it has been in the direction of improvement and refinement rather than the establishment of new principles.

It is the intention in the paper to show why there is reason to believe that a change may be impending, and why electronic cameras, with the vastly greater measure of operational flexibility that they can offer, may supersede the purely optical camera as the basic instrument of film production.

To substantiate such a view, the consequences of which would inevitably mean the introduction of far-reaching changes in film-production technique, it is necessary first to examine the characteristics of the traditional optical-mechanical instrument and then to determine how far those characteristics have themselves governed the technique. Secondly, it is relevant to consider why any instrument possessing what, in the view of the authors, are inherent limitations in its application should for so long have been accepted as the standard apparatus of the industry.

It is not suggested that the modern

Presented at The Institution of Electrical Engineers Convention on the British Contribution to Television, April 28–May 3, 1952, by Norman Collins and T. C. Macnamara, High-Definition Films, Ltd., 25 Catherine St., Aldwych, W.C. 2, England; reprinted from *J. Inst. Elec. Engrs.* (London), *99, Part III A, No. 20:* 673–679, 1952.

cinematograph camera bears more than superficial filial resemblance to the "magic boxes" of film-history. Indeed, the current models of orthodox equipment are elaborate instruments built to precision-engineering standards and modified in every detail by half a century of operational experience. In the result, there has been evolved a piece of apparatus of known and highly efficient optical characteristics, proved reliability in performance and general simplicity of maintenance.

Nevertheless, its basic principles remain unaltered. It persists as essentially an instrument to record a sufficiently rapid succession of single images of successive stages of movement within the framework of a single scene for the eye to be deceived by the illusion of continuous movement when the recorded images are subsequently projected. If a visual succession showing two different views of the same scene (as in a "cut" from a medium shot to a close-up), or two views of entirely different scenes (as in a cut from an interior to an exterior), is required the camera must occupy two different shooting positions, and the resultant film recordings must be joined together before the effect of the visual succession can be artistically evaluated. Furthermore, if the image of one scene is to be superimposed upon another (as in a "mix") it is necessary to go beyond the resources of the camera altogether and make use of the additional optical processes of the laboratory. In short, the single optical camera by its nature has to be assisted artificially before it can provide the multiplicity of recorded impressions from different viewpoints that the modern entertainment film requires.

Moreover, by its nature the optical camera is secretive in operation and reticent about its viewpoint until the exposed film has been developed. At most the camera shares its view with the camera operator; others — the director, for instance — may examine the scene in the view-finder before "shooting" begins, but in the result the utmost that can then be said with confidence is that the image appeared thus at the time of the examination and is not by any means how the image will necessarily appear when the camera actually begins operation. The significance of this should not be overlooked, for it means that, at the moment of shooting, the director is inevitably excluded; he becomes, as it were, an onlooker.

It is not, indeed, until after the development and projection of the "rushes" that the director is in any position to know whether or not he has achieved the original artistic purpose which lay behind the "shot." And it is because of this inability to pronounce judgment at the time that the prudent director often covers his misgivings by one or more "re-takes," in order to ensure that some part of the exposed film depicts the action as he wishes it.

It is sometimes argued that the unavoidable period of waiting before being able to study the projected film is not injurious to the end-product but is, in fact, positively beneficial. The view has been expressed that the technical perfection of the finished film can be obtained only by these two distinct processes — the totally undistracted shooting of individual and unrelated scenes in the studio, followed by the far more leisurely assessment of the "rushes" when they are projected upon the screen in the viewing theatre.

Such a view may well rest upon a confusion of cause and effect, and may indeed conceal a misconception of proper artistic method, for it can be argued that, with the facilities offered by the present type of camera, no other procedure could possibly be employed.

It now becomes profitable to consider the relationship of the individual shots to each other. It will be accepted by most film-makers that a great — possibly the greater — part of the artistic merit of the finished film, i.e. its effect upon the audience, will ultimately depend as much upon the juxtaposition of sequences as

upon the merits of the individual shots themselves.

In film-making under present conditions, however, the director is denied the possibility of any prior judgment on this point. He is compelled to rely upon "assembly" or "rough-cut" of the rushes before he can begin to evaluate these juxtapositions properly. By then it is frequently too late, except at considerable expense, to add what is discovered to be missing or to put right what is found to be wrong; furthermore, it is not until this stage that it can be realized that certain shots which are satisfactory in themselves are nevertheless redundant.

Nor is it surprising that this state of affairs should be so; because of the nature of the medium in which he is working, the director is in the position of an artist denied the facility of sketching-in the general outline of his picture and therefore forced to bring the various details to perfection as he proceeds. It should be recognized that the only outline to which the director can refer is his shooting script. This can, however, prove a false and misleading guide, inasmuch as the whole art of film-making consists of the translation of a literary form into a visual one, and it is only visually that the finished result can be judged.

(2) The Technique of the Electronic Camera

The use of the electronic camera — or rather a unit of three or four such cameras — will obviate many if not all of the difficulties which confront the film director who is employing single optical equipment. It is of the essence of the electronic method employing more than one camera that, during both rehearsal and shooting, the director can view upon his monitor screen not merely isolated shots but complete sequences (i.e. the blended output of his several cameras) of whatever length he may desire. The director can thus study the "architecture" of the film whilst the construction of the whole is still being composed, and the element of artistic hazard intrinsic in multiple-camera working with purely optical cameras is entirely avoided.

The film industry has already shown its awareness of the contribution which the electronic camera can make to smooth-running studio production by the introduction of an electronic aid in the form of a view-finder used in conjunction with multiple optical cameras. The advantages possessed by the combination of optical camera and electronic view-finder may be roughly summarized as follows. First, the element of operational blindness is removed; the director can study a camera-view of the shot during both rehearsal and the actual shooting. He can satisfy himself that the *découpage*, i.e. the breakdown into shots and angles, is as effective visually as it appears to be on paper. He can, whilst there is still time to alter or modify his own intentions, watch continuous sequences, and he is no longer compelled to work in a series of discontinuous glimpses. Finally, the electronic image can be multiplied and distributed, so that other key workers — the producer, the lighting engineer, the make-up supervisor, etc. — can exercise their own separate supervisions.

Because of these advantages the addition of the electronic view-finder to an orthodox camera is regarded as a progressive step; nevertheless, it is essentially a traditionalist solution to a problem which is amenable to more satisfactory solution by newer methods. If the electronic image produced by the view-finder on the camera (or rather the master image produced by the several view-finders on the various cameras in the unit) already exists in convenient form, the most rewarding course would be to improve the quality of that image until it attains technical parity with normal film, and then to photograph the master image itself rather than turn back to the individual cameras for the actual process of recording.

The advantages inherent in this method will already be apparent to any director who is familiar with modern television-studio technique. Once the electronic camera has been substituted for the optical camera within the studio the electronic image on the director's master-screen becomes not merely an accurate and helpful camera-eye view of the scene, but an identical reproduction, faithful in all respects with regard to lighting, focus, tonal gradation, brilliance, etc., of the picture which is to be, or is being, recorded. Moreover, the photography has taken place at the point where the contribution of the electronic unit and of the director's supervising intelligence are at their optimum. Not only can the "cuts," "fades," and "wipes" be recorded precisely as the director wishes, but this facility extends automatically also to mixes and superimpositions. Thus, at the end of shooting it is a portion of the fully finished film, rather than a collection of shots needing processing and editing, which the director of an electronic camera-unit has in his possession.

It is not the purpose of the paper to consider the advantages, in terms both of financial economy and of improvement in acting standards, which sequence shooting provides in comparison with the separate-shot method. The main issue is the question of the technical quality of recordings made from an electronic image. It remains, therefore, to show the reasoning which leads to the belief that recordings made by this method can produce film of fully acceptable technical quality.

(3) Overall Technical Considerations

It is clear that, to be acceptable, motion pictures made by the process described in the paper must to all practical intents and purposes be indistinguishable from those made by ordinary optical methods. This being so, an assessment of the average technical quality of pictures intended for theatrical release must be made, in order to determine the standard of technical performance which has to be achieved to attain the requisite effect. This is a difficult process, complicated by the profound influence of the artistic and entertainment value of the product, but whilst recognizing the overwhelming importance of these qualities in their proper sphere, the engineer must endeavour to disregard them and evaluate such purely technical quantities as he can. Even when he can assign objective values to the more measurable qualities, his task is still formidable, because the final result will be judged subjectively and no two people will agree what constitutes the most acceptable product when it comes to the portrayal of some particular scene. The most important qualities which must be assessed are, in order of relative importance, tonal range and fidelity of tonal reproduction, and picture definition.

(*3.1*) *Contrast Range:* Dealing first with tonal fidelity and excluding specialized shots where unusually small or distorted contrast ranges are used for special effects, it is generally conceded that the average motion-picture-film print has a useful detail-bearing contrast range of 0.2–1.5, expressed in terms of density = log $1/x$, where x is the transmission coefficient.

Extreme highlights, such as reflections from chromium-plated parts of motor cars, musical instruments, sequins and to a lesser extent glints in eyes, shine on hair, etc., are permitted to extend to a value of about 0.1, which is the density of the celluloid base and constitutes a burnt-out highlight which contains no detail, but the presence of which is essential to give sparkle to the picture. At the other end of the scale, there is usually no great advantage in reproducing dark areas of density greater than 1.5 with any detail, because the ambient light falling on the screen is sufficient to flatten them out, owing to requirements of safety lighting in theatres. Nevertheless, it is customary to permit extremely dark areas

to reach a density substantially below 1.5 without, however, containing much detail.

It may thus be said that the detail-bearing contrast range in an average motion-picture film, expressed in linear terms, is antilog (1.5–0.2) = 20:1. Allowing for extension to burnt-out highlights at one end of the scale (density = 0.1) and extreme blacks at the other (density = 1.7), the total contrast range is probably some 40:1 in the print itself.

It does not follow that this range of contrast will always be realized on the screen when the film is projected, because the actual limits of reproduction will vary enormously with many factors. The quality of the illuminant and optical system of the projector, the amount of ambient light reflected on to the screen by different decorative schemes in the auditorium and many other things all contribute to reduce the effective contrast of the picture.

These considerations aside, however, it seems clear that, to be comparable with normal motion-picture film, the release prints of motion pictures made by the proposed electronic process must have a total maximum contrast-range of some 40 or 50:1.

For the contrast characteristic required, normal practice in motion pictures is to work to an overall gamma of about 1.3, which corresponds to a mean gamma of about unity. It is clearly desirable that films made by the electronic method should conform to this convention and there is no difficulty in achieving this result. In fact, the electronic process offers the possibility of improvement, because the extreme flexibility of the electronic chain through which the signals corresponding to picture are passed allows almost any shape of transfer characteristic to be contrived, within broad limits determined by the signal/noise ratio.

This is very significant, because it means that inherent defects in photographs, which are cumulative throughout the printing and processing and which result in a far from ideal characteristic in the final product, can be corrected by electronic compensation when the electronic camera is used, whereas they have to be tolerated when only the ordinary optical camera is available. As a result, the film produced by electronic means should ultimately be superior in tonal quality to that made by normal optical methods.

(*3.2*) *Definition:* The study of definition in a photographic image is a difficult subject, and too much adherence to conventional approaches can lead to erroneous conclusion. A somewhat novel approach to the problem has therefore been evolved, in the hope that methods of measurement may emerge which are capable of yielding more realistic results than some of the methods used in the past.

For example, the resolving power of a lens or a film stock, or a combination of the two, is usually defined as a limiting resolution of so many lines per millimeter. This means that an image composed of a pattern of that line density is just discernible, i.e. it is an extinction value. Any detail finer than this is lost, falling within the circle of confusion of the lens or the film grain size, or some combination of the two.

This definition by itself is misleading in assessing the effective sharpness of the resultant picture. The limiting resolution figure is analogous to the ultimate cut-off frequency of a low-pass filter, or, with certain minor reservations, of any piece of television equipment, such as a video-frequency amplifier or television broadcast transmitter. It gives no indication of the performance of the equipment at frequencies in the pass region below cut-off.

Obviously, many factors, such as lens aberrations, flare, internal reflections and diffusion of light and grain structure in the photographic emulsion, etc., must contribute to this fall-off in response as

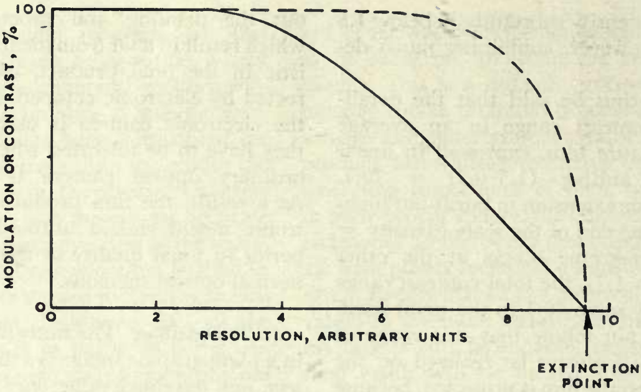


Fig. 1. Comparison of photographic contrast with television depth of modulation over total range of resolution.
——— Photography; resolution in terms of lines/mm.
- - - Television; resolution in terms of detail frequency.

the detail fineness approaches the limiting resolution or extinction value, but a mere statement of the resolving power does not disclose the rate at which the fall-off takes place.

In an attempt to reconcile the television and optical points of view, the authors propose to use a term which has come to be used, namely "detail frequency," which is the product of the number of lines per millimeter into which the object is dissected and the scanning speed. Detail frequency in television is thus the electrical counterpart of detail fineness in photography and its use permits comparisons to be made. It must be recalled, however, that 1 line/mm in photographic practice conventionally represents one white and one black line, whereas in television the black and white lines are counted separately, i.e. one photographic line equals two television lines. It must be added, moreover, that the detail frequency is to be regarded as the fundamental frequency generated by scanning a repetitive pattern. No account is taken of harmonic development at this stage.

Figure 1 shows an arbitrary comparison between the detail-frequency response of a television system and the detail response of a lens and photographic emulsion in comparable terms. To illustrate the point, the lens and film combination have been shown as having something approaching a normal aperture/distortion curve, whereas the television-system response has been maintained at 100% almost up to a sharp cut-off. The limiting resolution is the same in both cases.

It is believed that of the two reproducing systems, television will present a picture giving a greater subjective impression of sharpness and boldness of detail than the other, even though the detail cut-off frequencies are the same in both cases. The theory is advanced that subjective impression of definition can in some way be related to the ratio of the respective areas below the curves. The determination of this effect is complicated — like all comparisons of definition between television and photography — by the fact that television pictures are discontinuous in the vertical plane, whereas photographs are continuous in both planes. However, this does not necessarily invalidate the truth of the conception.

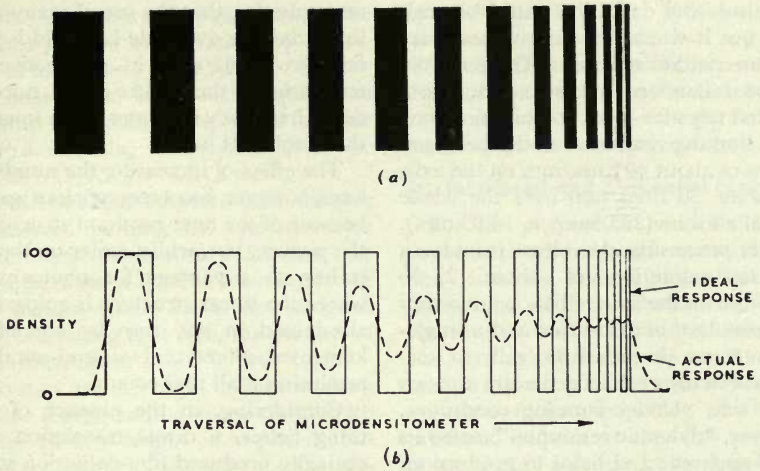


Fig. 2. Detail resolution test: (a) test card; (b) photographic image.

Another way of considering the same effect is to study the rate of change from black to white (and vice versa) attainable in photography. It is known that the transition from black to white in a photographic image is not infinitely rapid. In other words, the density change at the edge of an exposed area is gradual and not abrupt. Discounting contributions due to lack of sharpness in the lens, the main cause of the effect is hallation or dispersion in the grain of the emulsion. To demonstrate this effect, an image of alternate black and white bars of progressively smaller dimensions is explored by means of a microdensitometer, which is capable of measuring the density of areas small by comparison with the width of the narrowest bar.

The results of such an exploration are shown (greatly exaggerated) in Fig. 2. The full curve illustrates the ideal response, and the dotted curve the general shape of results attained in practice. It becomes apparent that the effect is precisely analogous with the distortion of a square wave which has been passed through an amplifier with an insufficiently short rise-time.

Investigation shows that the "rise-time" of different photographic emulsions varies greatly, for example, with grain size, etc., and it is not necessarily those emulsions that are capable of the greatest absolute resolution that possess the shortest rise-time for a black-and-white pattern of given fineness. It is believed that the picture which gives the best subjective impression of sharpness is the one that possesses maximum depth of modulation at higher frequencies and most rapid rise time, and that a figure of merit of apparent sharpness can be extracted, based on a mathematical combination of these two values. It will therefore be seen that to evaluate the quality of average motion-picture definition and to translate the result into terms of equal television definition is not a simple process. In consequence, it has been necessary to base the calculations on a simple conversion using such values as are generally accepted.

Before proceeding to numerical values it seems desirable to recognize that motion-picture technicians have, over a long period, arrived empirically at an order of definition which is adequate to satisfy the most discerning member of the public, even when sometimes projected through rather mediocre equipment. There is little doubt that twice or even

four times the definition could be realized, but it would be quite unnecessary and uneconomic to do so. The generally accepted standard seems to comprise a lens and negative-stock combination having a limiting resolution under best conditions of about 40 lines/mm on the axis, and some 30 lines/mm over the whole field of a frame (22.05mm $\times$ 16.03 mm).

After processing, the release print has a limiting resolution of about 25–30 lines/mm on the axis. This is not a very high standard of definition, and a single-35mm frame projected statically to normal screen dimensions generally appears fairly soft. Under running conditions, however, "dynamic resolution" makes its effect apparent and helps to produce an impression of adequate sharpness.

The mechanism of the dynamic-resolution effect lies in the fact that surface noise is random and adds from frame to frame in quadrature. The image, on the other hand, is repetitive and therefore tends to add arithmetically over a number of frames; moreover, the sharpness of edges is improved because a random succession of film grains, as it were, scan them and sharply delineate them.

For the choice of standards of electronic-image definition to give results comparable with motion-picture film produced by normal methods, it is necessary to consider the order of resolution required and that realizable in the present state of electronics. So far as image dissection is concerned, the only variable quantity is the number of lines, since the picture repetition frequency is fixed by motion-picture standards at 24 frames/sec. The decision regarding the number of lines controls many factors, of which the bandwidth of the system, the signal/noise ratio and the size of the scanning spot at both camera and reproducing tube are of cardinal importance. It is well known that, for a given number of lines, there is a calculable bandwidth which must be used in order to produce definition which is equal in both vertical and horizontal directions. It is worth remembering that the use of many more lines than the available bandwidth justifies can result only in progressive deterioration of the picture detail, since the detail frequency increases as the square of the number of lines.

The effect of increasing the number of lines, however, has a meretricious appeal, because of the finer resultant structure of the picture, but, whilst easier on the eye, it has no advantage for photography, where the linear structure is going to be eliminated in any case by one of the known expedients and out-and-out detail resolution is all that counts.

Considering, in the absence of anything better, a direct translation from optically produced film-definition standard to television, the following assembly of facts is arrived at:

The resolution of a normal motion-picture negative has been assessed, at best, to be about 40 lines/mm, which represents 80 television-picture points per millimeter.

Since the frame is 22.05mm wide, the definition along the line is equivalent to a total of $80 \times 22.05 = 1{,}764$ picture points.

This, however, is based on photographic limiting-resolution values, so that it seems possible, in the light of the foregoing arguments, that appreciably less television picture points would suffice to produce a picture of acceptable sharpness. In this connection, Kemp* has suggested that it would be permissible to introduce a factor *C*, of which he considers the value to be about 0.75, to compensate for the more rapid decay of response of the photographic system with increasing fineness of detail, as opposed to the maintenance of a high level of television modulation up to the frequency of cut-off. Application of this factor gives the definition along the lines as the equivalent of $1{,}764 \times 0.75 = 1{,}323$ picture

*W. D. Kemp, "Television recording," *J. Inst. Elec. Engrs.*, [London], *99, Part III A, No. 17:* 115–127, 1952.

points. Direct translation of this value into the number of lines from top to bottom of the picture gives $1{,}323 \times 0.75 = 992$ lines. The bandwidth required to transmit this detail, given by the familiar $L^2RP/2$ formula, is therefore $(992^2 \times 4 \times 24)/(3 \times 2) = 15.75$ mc.

It will be argued that it would not give a balanced picture, i.e. one in which vertical and horizontal definitions are equal, because of the line scanning factor K. Various values have been assigned to K, but taking it at 0.75, the number of lines is increased to $992/0.75 = 1{,}320$.

To sum up, therefore, definition along the line corresponding to one-thousandth of the picture height is required, but to take account of diversity in the discontinuous vertical direction, the number of scanning lines may have to be increased to 1,300 with a 25% increase in bandwidth to cater for the increased scanning speed.

However, because of the probably greater incidence of vertical than horizontal lines in a natural scene, it may not prove necessary to go much above 1,000 lines, and, since there is a tremendous advantage in keeping the writing speed as low as possible, this figure has been taken as a basis for first experiments.

It must be emphasized that the whole of the foregoing is advanced with extreme reserve and is, moreover, the subject of experiments currently being made, as much of it is based on pure supposition and on theories which have always been the subject of fierce controversy. Doubtless, calculations on other bases would yield widely divergent results, but the authors feel that it is essential to make some attempt to determine numerical values, as a starting point for practical investigation.

Quite apart from the foregoing, there remains the possibility of introducing novel means of picture dissection — which may prove more adaptable than scanning of the orthodox variety — to the production of motion-picture film by television methods. It is too early, however, to make more than a passing reference to such possibilities, and for the purpose of the paper the authors have confined their consideration to scanning of the conventional type.

(4) Interlaced and Sequential Scanning

For the purpose in hand the choice between interlaced and sequential scanning involves several important considerations. Interlaced scanning is universally used for broadcast television and, in this connection, is an extremely useful expedient. By interlacing, the apparent flicker frequency of the reproduced picture is doubled, without, however, any increase in the bandwidth required to transmit it. The principle of interlacing therefore possesses outstanding advantages for broadcasting in that its use transforms a television picture of comparatively low repetition frequency, which would exhibit considerable flicker if sequentially scanned, into one which within acceptable limits of brightness is effectively flicker free.

On the other hand, the introduction of interlacing is generally held to reduce the apparent definition of the picture as viewed by the eye. A number of effects are involved, of which three may be cited. First, slight inaccuracies of registration of the interlace raster result in "pairing" of the scanning lines, or, in extreme cases, superimposition of the lace and interlace lines. This is bound to reduce the definition progressively as the pairing effect becomes worse, until complete superimposition occurs, when the definition is theoretically halved. It is only fair to record that advances in design of scanning circuits have greatly reduced this defect in the last year or so.

Secondly, the movement of the viewer's eye when following vertically moving objects strobes the line structure and momentarily breaks the picture as seen into half the number of lines, giving the impression of a coarse line-structure. A similar effect occurs in

the television camera, where strobing can take place between the line scanning and objects moving up or down the vertical axis of the picture. Tilting of the camera can produce the same effect. It must be noted that in the recording of a television picture strobing effects are confined to the electronic pick-up camera and do not occur at the photographing point, because the photographic camera has a fixed viewpoint. Nevertheless, even in its reduced form, the result of "line crawl" introduced by the camera can be quite serious.

Thirdly, the use of interlacing gives rise to a particularly objectionable form of movement blur, because two discrete and separate images of a fast-moving object appear on the screen, displaced from one another by the distance through which the object has moved in the $\frac{1}{48}$-sec interval between the writing of the two superimposed rasters. This is a form of movement blur which finds no counterpart in the natural response of the eye or in normal cinematography.

On the question of recording television images on film, however, it will be immediately apparent that the need for interlacing fundamentally does not exist, because the standard picture repetition rate is 24 frames/sec, elimination of flicker being effected at the film projector, where the light is obdurated twice, or preferably three times, during the projection of each picture frame.

Freedom to use sequential scanning leads to a consideration of its advantages, which may be stated as follows:

(a) It is appreciably easier to obtain accurate registration of the lines in a sequential than in an interlaced raster.

(b) Movement blur, due to the formation of double images, and line crawl are eliminated.

(c) The obligation to produce an exact number of lines per frame no longer exists, which opens up possibilities of the introduction of advantageous effects analogous to the dynamic-definition effect.

(d) The number of frame-suppression periods per picture is reduced from two to one, thus materially increasing the "time efficiency" of the system.

It is thus suggested that sequential scanning presents so many advantages that its use is to be preferred. The serious disadvantage lies in the fact that the pictures viewed by eye, during production, suffer from the severe disadvantage of 24-cycle/sec flicker. There seems some hope, however, that the effect of flicker may be to a large extent reduced by the use of reproducing cathode-ray-tube screens having long decay times.

(5) The Electronic Camera

(*5.1*) *Brief Description of System:* To summarize the foregoing, it would appear that the use of a 1,000- to 1,300-line sequentially-scanned electronic image with a bandwidth of 15 to 20 mc will suffice to give adequate definition for the production of acceptable motion-picture film, provided that the whole system is sufficiently free from loss and distortion. The contention is advanced that definition of this order is within range of modern electronic equipment and that, within a short time, equipment which has been developed in the laboratory will be available in a form which will be suitable for use on the studio floor.

(*5.2*) *Optical Performance:* No limitation in definition is imposed on the system by the taking lens of the electronic camera, since good-quality 35mm lenses of to-day are capable at full aperture of resolving from 8 to 10 times the fineness of detail normally required for making a film optically. The use of a standard range of 35mm lenses also ensures that depth of focus, taking angles and so on, are exactly similar to those to which film technicians are accustomed.

(*5.3*) *Handling Characteristics:* Electronic cameras can be made in conventional shape, but much smaller and

lighter than their optical counterparts. No form of "blimp" is necessary, because the electronic camera is completely silent. No necessity for reloading exists, and the cameras will operate for long periods without attention.

Apart from this, the camera handles in exactly the same way as any film camera, and the camera operator, if he so wishes, may adopt entirely conventional methods of view-finding, focus-pulling, etc. On the other hand, he has open to him entirely new features, such as cathode-ray view-finder, remote turret and iris operation, as well as facilities for remote or even automatic focusing, including splitting focus.

Only time can show how he will choose to employ these facilities, but it seems very probable that a technique can be built up using some or all of them with a material increase in efficiency of working.

(*5.4*) *Technical Performance Requirements:* The electronic camera must be capable of resolving some 1,000–1,300 lines and generating a substantial amplitude of signal up to the highest detail frequency.

The photometric response must be such that a substantially linear characteristic can be obtained, with correction, if necessary, for a 50:1 range of light intensity.

The signal/noise ratio of the whole system must be not worse than −30 db on peak white.

The camera must be free from shading and vignetting effects and spurious signals generally, and it must maintain constant illumination over the field and a constant black level under the exacting conditions of practice.

The sensitivity of the whole system must be at least equal to or greater than that of a normal film camera used with fast negative stock, and the scanning geometry must be of a very high order of accuracy, say within 1% in terms of velocity.

The associated equipment must have sufficient gain for the purpose in hand and a handling capacity large enough to allow for pre-emphasis at the higher frequencies, if necessary. It must be free from phase distortion or overshoot generally.

Facilities must be provided for gain adjustment, shaping of amplitude characteristic and the introduction of pre-emphasis.

Finally, means must be provided for cutting, fading, mixing or superimposing the pictures from a number of cameras and introducing electronic wipes, overlays, matte and other process shots, as well as programme material derived by telecine scanning of film taken elsewhere of exteriors, etc.

(6) Recording Cathode-Ray-Tube Unit

As in the camera, the scanning geometry of the recording unit must be of unimpeachable accuracy and the spot size sufficiently small to resolve the requisite definition without appreciable loss.

The tonal response must be either linear or capable of being shaped to compensate for the film-gradation characteristics. The maximum available peak brightness must be sufficient to reproduce the highest burnt-out highlight without "white flattening" or defocusing.

Steps must be taken to reduce dispersions or reflections of light so as to preserve the maximum contrast range, and the recording tube must be set up *vis-à-vis* the motion-picture recording camera in such a way as to minimize the effects of vibration.

(*6.1*) *The Mechanism of Photographic Recording:* The choice of a means of photographing the image on film in the form of a motion picture poses a number of serious questions. Numerous methods have been proposed to bring about the desired result, but, broadly speaking, practicable methods tend to fall into one of two main categories, namely inter-

mittent or continuous motion. The relative merits of the two systems, in their various applications to television recording are discussed by Kemp (*loc. cit.*), and there is therefore no need to enlarge upon them here.

It must be noted, however, that Kemp's approach to the problem is conditioned by the fact that his treatment concerns the problems of recording broadcast television, where the worker is presented with a composite signal intended for reception on a normal television receiver. The form of this signal is fixed and he cannot in any way vary it.

The authors, on the other hand, are at liberty to make any changes in signal waveform that they see fit and consequently their conclusions are influenced by the greater degree of freedom open to them, as well as by the fact that they are working to much higher standards of definition, which in turn bring special problems.

Whilst there can be no doubt that continuous motion is exceedingly attractive from many points of view and may prove to be the ultimate solution, the accuracy of registration which can be realized in the present state of development is insufficient for recording pictures of the order of definition required. In consequence, attention has been directed to the intermittent system, which has been proved by many years' use in the motion-picture industry to give a very high degree of accuracy of registration.

The application of the intermittent movement to the problem of recording high-definition electronic images has, of course, been greatly eased by the freedom to adapt the signal waveform to suit the operating conditions of the photographic camera.

To illustrate the degree of this easement, consider the case of recording broadcast television with an intermittent camera. If the maximum picture information is to be recorded, the film shift must take place completely within every other frame-suppression interval. This means that the film must be accelerated, decelerated, brought to rest and registered in a period of 14 television lines, which represents a time interval of about 1.4 millisec, or 12° rotation of the film-camera mechanism.

Expert opinion indicates that a film shift of this speed is on the limits of possibility, and that even if improved design enabled it to be realized, the strain on both film perforations and mechanism would be such as to make frequent jams and stoppages unavoidable and to render maintenance extremely difficult and costly.

No such mandatory condition exists in the requirements of the proposed system of high-definition recording, and it is possible to choose a frame-suppression interval of any length desired. Any increase would, of course, be made at the expense of the time efficiency of the system, i.e. the ratio of the time during which information is passing to the time during which the system is inoperative during suppression. Nevertheless, a useful compromise may be struck in which the gains accruing from the use of a longer frame-suppression period outweigh the loss in terms of time efficiency.

As stated earlier, the use of sequential scanning gives a substantial gain over interlaced scanning, since there is only one frame-suppression period per frame in the former as against two in the latter. The authors, therefore, advocate an intermittent camera with an accelerated film-shift operating during the frame-suppression period.

(*6.2*) *Exposure Time and Movement Blur:* Some consideration must be given to exposure time in an electronic, as opposed to a photographic, camera. In normal motion-picture work, the maximum available exposure is usually 180°, and although practice varies, the usual run of pictures is shot at full exposure. Shorter exposures, obtained by reducing the shutter-opening angle, are generally used only for scientific investigations.

The effect of using a comparatively long exposure of, say, $\frac{1}{48}$-sec in a photographic motion-picture camera is to produce a measure of movement blur, which is usually regarded as beneficial in smoothing out movement and preventing the formation of discrete separate images of a fast-moving object in successive frames. Picture-goers are used to this effect, and it enhances the impression of movement as portrayed on the screen.

In the high-definition electronic camera, the actual time the scanning beam is traversing each picture point is about $\frac{1}{48}$ microsec, or a million-times shorter exposure, since this would be the effective exposure if the camera had no memory effect. Fortunately all electronic cameras have some "memory," and it is possible to proportion the memory to give an adequate impression of movement.

In the early days of television broadcasting some cameras had a very short memory, and a fast-travelling ball, for instance, appeared as a line of white dots. An exceptionally long memory, on the other hand, is equally disadvantageous, because under these conditions very serious blurring will occur on moving objects and when the camera is panned.

A compromise is therefore necessary, and motion-picture experience indicates that a storage memory of 0.25–0.5 frame in length is likely to be satisfactory. It is not thought that the effect is particularly critical, and most television cameras in use to-day do not show any unpleasant effects in this connection under any reasonable conditions of working.

(7) Choice of Film Stock

A considerable degree of latitude exists in the choice of film stock for the recording camera, by virtue of the fact that the amount of light emitted by the recording cathode-ray tube is independent of studio illumination and may be kept constant under all conditions. Processing to constant gamma as opposed to constant density is facilitated by this.

Moreover, much more light is available at the film than when it is exposed in an optical camera, not only because the intensity of light emitted by the cathode-ray tube may be made several times that of the light reflected from a studio scene, but also because the optical system used with the photographic recording camera can be made more efficient than that which it is possible to use on a studio floor. Magnification is constant and negligible depth of focus is required, because the cathode-ray screen is a flat field.

In consequence, comparatively slow film stocks can be used, with advantage in terms of resolution, rise time, absence of granularity and linearity of tonal characteristic. Moreover, images on fine-grain negative are known to suffer proportionately less in processing and printing than those on more sensitive and coarser-grained emulsions.

(8) Conclusion

Whilst encouraged by the results of laboratory and studio tests to date, the authors are conscious that the paper is necessarily tentative in its conclusions and is in many respects lacking in precise data. However, in view of the rapidly developing interest in electronic film-making, they felt that an interim paper of this nature would nevertheless be of interest.

(9) Acknowledgments

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Discussion for This Reprinting

By Pierre Mertz

The paper by Messrs. Collins and Macnamara describes a proposal that will be followed with great interest, for the application of television to motion picture production techniques. The objective "that, to be acceptable, motion pictures made by the process described in the paper must to all practical intents and purposes be indistinguishable from those made by ordinary optical methods" will appear especially challenging.

A point which the authors undoubtedly have in mind, but do not emphasize, is that in large measure the television processing which they are proposing is to be inserted in tandem with the photographic and optical techniques at present existing. Thus to set detailed objectives on quality it is necessary to investigate not merely the performance of the latter processes, but also the additional impairment expected from the insertion of the television processing. In such a case, in general, the inserted impairments need to be not simply of the same order of magnitude as those already existing (in the optical and photographic processes) but one or two orders of magnitude lower.

The authors are diffident about the tentativeness and controversial nature of their data and conclusions on photographic and television performance. Because of this it would seem helpful in a number of places if they could give documentation for the data they introduce. In particular, the authors have not referred to the extensive work of Otto Schade[1] on many questions which apply closely to their problem Other specific points upon which documentation would be helpful are:

(a) The film density ranges mentioned by the authors seem modest compared to the projection density measurements reported by Tuttle[2] in 1936. Tuttle's minimum densities run a bit higher than the authors': at low, 0.18; median, 0.41; and high, 1.05. His maximum densities, however, run substantially higher: namely, low, 1.90; median, 2.21; and high, 2.65. The influence of stray light in the theater on the projection contrast was discussed in a symposium of the SMPTE in May 1951.[3] S. K. Guth, in particular,[4] mentions a maximum desirable level giving 0.07 ft-L on the screen (which has a clear screen brightness of 5 ft-L). This leads to an equivalent density of 1.85, which still is over the authors' allowance of 1.7.

(b) The authors' figures on motion picture definition correspond generally with those found by an SMPTE committee in 1946 and referred to by Schlafly[5] in 1951. It would be interesting, however, to have more specific information on the "good-quality 35mm lenses of today . . . capable at full aperture of resolving from 8 to 10 times the fineness of detail normally required for making a film optically."

(c) The explanation which the authors give of "dynamic resolution" is the conventional one. However, in any casual experience which I have had, the increase over the "static resolution" was not realized, possibly due to "jump" and "weave" of the picture. It would be interesting to have any documentation on actual experiments which the authors might know of.

(d) Again on the subject of definition,

At the request of the Chairman of the Society's Board of Editors, at the time of reviewing this paper, this discussion was prepared by Pierre Mertz, Bell Telephone Laboratories, Inc., 463 West St., New York 14, N.Y.

the Fig. 1 which the authors show represents the familiar sharp drop in television resolution towards the extinction point. However, it has been shown in the work by Schade that if the influence of terminal equipment is considered in addition to that of the electrical circuit, the shape of the characteristic obtained shows a gradual drop, not too different from the photographic characteristic. This is illustrated, for example, by Figs. 100 and 101 of the 1948 paper.[6]

(e) The authors attribute to Kemp a suggestion for the use of a factor C = 0.75 to compensate for the decay, towards the extinction point, of the resolution of the photographic as compared with the television system. I have read through the Kemp paper referred to, No. 1351, fairly carefully but cannot find the suggestion.

(f) The authors mention a proposed signal-to-noise ratio requirement, to avoid degrading the film picture, of 30 db. American estimates of the performance of film run appreciably higher.[7] Figures (excluding allowances for synchronizing pulse and excluding frequency weighting) have been presented of 42 to 47 db, and even higher. Possibly the authors are measuring the random noise peak-to-peak, instead of rms, but even this would not account for all the apparent discrepancy. It is noted that no figures at all are given on specifications for shading or phase distortion, although these are apt to be important impairments in present-day television.

(g) It would be interesting to know if the authors have any specific information in mind on the "probably greater incidence of vertical than horizontal lines in a natural scene."

It is a little odd to find, after an admirable discussion of the advantages to be gained by the presentation to the director of exactly the picture which will ultimately be obtained from the film, that the authors are so little bothered by the problem of flicker on the director's monitor. With the use of the sequential scanning and the frame frequencies mentioned, together with a useful picture brightness, one wonders if the flicker will not be sufficient to ruin the director's artistic judgment. It would be interesting to have more information on the speculations regarding the possibilities of long decay phosphors in avoiding this, without unduly blurring the outlines of objects in motion.

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5. H. J. Schlafly, "Some comparative factors of picture resolution in television

and film industries," *Jour. SMPTE, 56:* 44–51, Jan. 1951.
6. O. H. Schade, from reference 1 above, *RCA Rev., 9:* see p. 678, Dec. 1948.
7. Pierre Mertz, "Data on random noise requirements for theater television," *Jour. SMPTE, 57:* 89–107, Aug. 1951.

Author's Comments

The authors were careful to point out that this paper was of an essentially interim nature, and did little beyond defining some of the major difficulties with which those who seek to make motion pictures by a television intermediate process are faced.

This being the case, the authors deliberately refrained from making reference to the very considerable amount of bibliography which exists on this subject.

The introduction of any additional process into a reproduction system must degrade the result *unless* the additional process can be made to correct errors in the process. It is certainly possible to apply electrical corrections for tone distortions introduced by the film characteristics, and by overemphasis of the higher detail frequencies it would appear also possible to correct in a large degree for aperture distortion, lens losses, etc. (As an analogy it is interesting to recall that the introduction of an electrical process into the recording of sound on disc — essentially a mechanical process — considerably improved the overall results.)

The authors, moreover, believe that other gains in terms of definition can be achieved. For example, it appears that the present average standard of quality in motion pictures has gradually advanced, against economic pressure, to a state where it is generally acceptable to the picture-going public. There seems good reason to suppose that if higher processing costs could be justified, marked improvements could be effected both in the production of the original negative and its subsequent reproduction through the stages leading up to the multiple release print.

The authors feel that if the economic advantages they claim for the process which they advocate are realized, some proportion of the savings will be available to improve the photographic part of the process with considerable gain in overall results.

Dealing now with the other points in the discussion, the authors would make the following comments:

(a) The film density ranges which they have mentioned were those quoted by a well-known manufacturer of film stock and the authors took them as a fair average basis on which to work. In point of fact there is no difficulty in extending the contrast range to any value which the film will accept so that the figures reported by Tuttle could be realized without serious difficulty.

(b) The authors admit that the statement that "good-quality 35mm lenses of today are capable at full aperture of resolving eight to ten times the fineness of detail normally required for making a film optically" is misleading if divorced from its original context, which was omitted from the paper at a late stage for security reasons. They can only repeat the view of a leading lens designer who states that "an $f/2$ lens can provide on Maximum Resolution Plates, 8 to 10 times the axial resolving power obtained with emulsions used in the film industry. Thus one could argue that it is the fact that the film industry uses grainy emulsions which defines fineness of detail."

The authors hold the view that this increased resolving power may to some extend be exploited.

(c) The authors believe that the conventional explanation of "dynamic resolution" is valid, and although it is difficult to establish quantitative results they have carried out a number of experiments which by observation were extremely convincing and in which the effect of dynamic resolution was most marked.

(d) The authors are only too well aware of the losses introduced by terminal equipment and as previously stated have been at pains to introduce into the electrical circuits corrections to compensate as far as possible for them. The limit to this process is, of course, the signal-to-noise ratio. To date they have been surprised

at the good signal-to-noise ratio they have been able to obtain.

By scrupulous attention to every element in the chain they have been able to preserve a good relationship between contrast in the object and in the image photographed on film up to the highest resolution powers of which the system is capable. They are confident that this result is capable of extension to higher definition by expedients which they hope to describe in due course. It should be mentioned in passing that particular attention has been given to the design of kinescope recording tube screens so as to maintain high contrast at the finest detail and eliminate as far as possible reflections and diffusion effects which militate against the desired result.

(e) The factor attributed to Kemp was omitted from the published version of his paper.

(f) The acceptable ratio between signal and noise seems to depend largely on the nature of the noise. The authors took a number of examples of optically produced film exhibiting normal grain structure and made a series of statistical tests against television picture recordings on fine-grain film in which the noise was of a fairly high-frequency type.

When the two results were adjudged to be as nearly comparable as could be determined by observation, the level of peak noise in the television picture was found to be some 30 db below peak white.

Had there been a preponderancy of low-frequency noise in the television picture it is highly probable that some ratio of the 40–50 db order would have been required, because not only is the high-frequency noise attenuated in the photographic process, but it is less apparent to the eye because of its finer structure.

As regards shading and phase distortion, the authors have worked to a condition of no visible shading in the photographic image, but with a progressive increase in brightness towards the edges of the picture amounting to some 15% at the extremes to compensate for lens vignetting. It has been found advantageous in some cases to overcorrect the final product to compensate for the projector objective. Phase compensation throughout the system is advocated so that no visible overshoot occurs at any frequency within the limits of the response of the system.

(g) The authors regret that they cannot quote any scientific evidence regarding the greater incidence of vertical as opposed to horizontal edges in a natural scene, but they have frequently heard the view expressed that the former tend to preponderate.

In conclusion, the question of flicker on the director's viewing screen has proved curiously unimportant. At a brightness consistent with fairly low levels of ambient illumination the flicker is singularly inobvious and after a few minutes the observer gets used to it and forgets it entirely. The wearing of dark glasses has been recommended and certainly assists in this connection, but never at any time during the authors' work has any serious complaint of flicker been voiced. Reproducing tubes having a moderate decay are used at present and the development of tubes having some approximation to a square decay has made some advance. Unfortunately, however, no information can be disclosed on such tubes at the present time for security reasons.

Signal Corps Mobile Television System

By JOHN S. AULD

The U.S. Army Signal Corps' mobile television system is briefly described. In this system five vehicles — a transmitter bus, transmitter power bus, receiver bus, receiver power bus, and kinescope recording bus — are used to provide a complete television unit designed to meet training and operational requirements of the Army.

In 1948, when television began to pass from its embryonic stage, the Army decided that it might be employed to answer some of its tactical and training problems. Television had been used during the latter phase of World War II on an experimental basis, using highly specialized nonstandard equipment, with excellent results.

The question arose as to what units would receive television equipment, what type, and how would it be employed? It was decided that the most practical and economical method of answering these questions was to design one complete and self-contained system on wheels. This unit could then travel from post to post stimulating thought, and showing field commanders of the various branches of service (i.e. artillery infantry, etc.) how television might solve some of their particular problems. The information obtained from these demonstrations would then form the basis for specifications of specialized equipment to meet these individual needs. This was the inception of the Signal Corps Mobile Television System.

Presented on October 7, 1952 at the Society's Convention at Washington, D.C., by Sgt. John S. Auld, Technical Director, U.S. Army Signal Corps Mobile Television System, Signal Corps Photographic Center, 35–11 35 Ave., Long Island City 1, N.Y.

The Transmitter Bus

The basic layout of this vehicle is quite similar to that of the average commercial remote pickup bus but, because it has to provide all the station programming facilities, it is much more elaborately equipped.

This unit houses three, RCA Type TK-30A, field camera chains. The camera controls and power supplies are placed console fashion across the rear of the bus. Behind this operating position there are five cable reels. Four of these carry 250 ft of camera cable each; the fifth, 1700 ft of microphone cable of various convenient lengths.

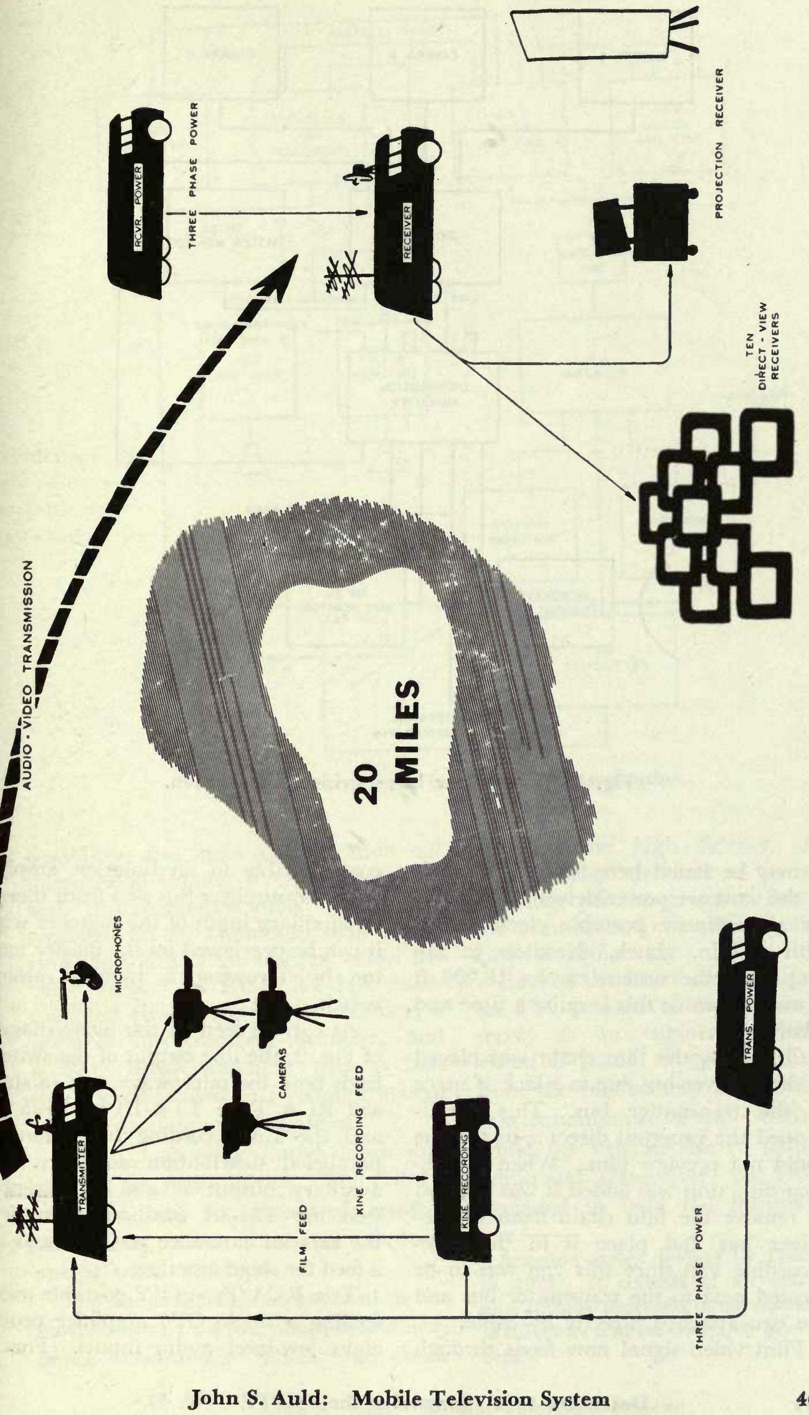

Fig. 1. Flow chart of the Signal Corps Mobile Television System.

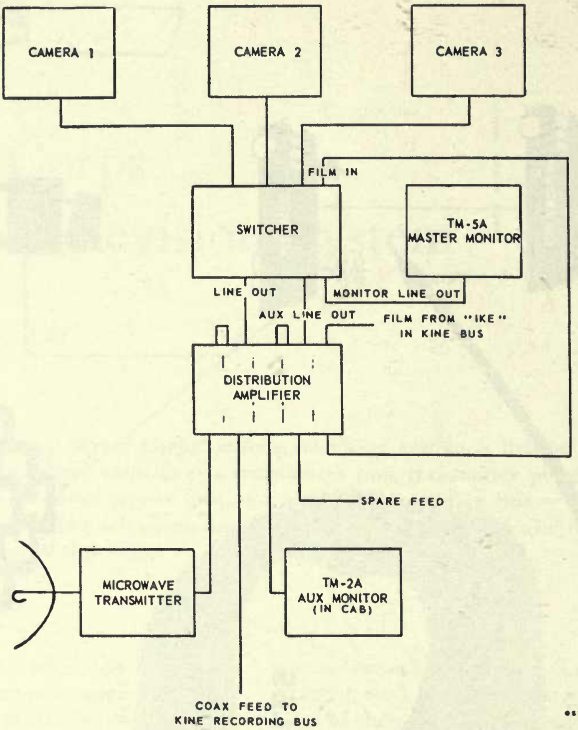

Fig. 2. Transmitter bus — video distribution.

It may be stated here that all the reels in the vans are power-driven on take-up by an ordinary portable electric drill with a $\frac{1}{2}$-in. chuck. Needless to say that since the system carries 18,000 ft of assorted cable this is quite a time and labor saver.

Originally the film chain was placed in the receiver bus due to a lack of space in the transmitter bus. This handicapped the program director in that he could not preview film. When a kine-recording unit was added it was decided to remove the film chain from the receiver bus and place it in the kine-recording van since this van was to be located next to the transmitter bus and the two attached directly by cable.

Film video signal now feeds through coaxial cable to an isolation amplifier in the transmitter bus and from there to an auxiliary input of the switcher where it can be previewed on the master monitor by throwing a monitor selector switch.

As can be seen in the block diagram of Fig. 2, the line output of the switcher feeds both the microwave unit (a standard RCA Type TTR-1B on 7125 mc) and the kine-recording bus through a paralleled distribution amplifier. The auxiliary output is also paralleled to feed the TM-2A auxiliary monitor in the cab, an announce position, and also a feed for stage monitor.

Two RCA Type OP7 portable mixers feeding a single OP6 amplifier provide eight low-level audio inputs. For ac-

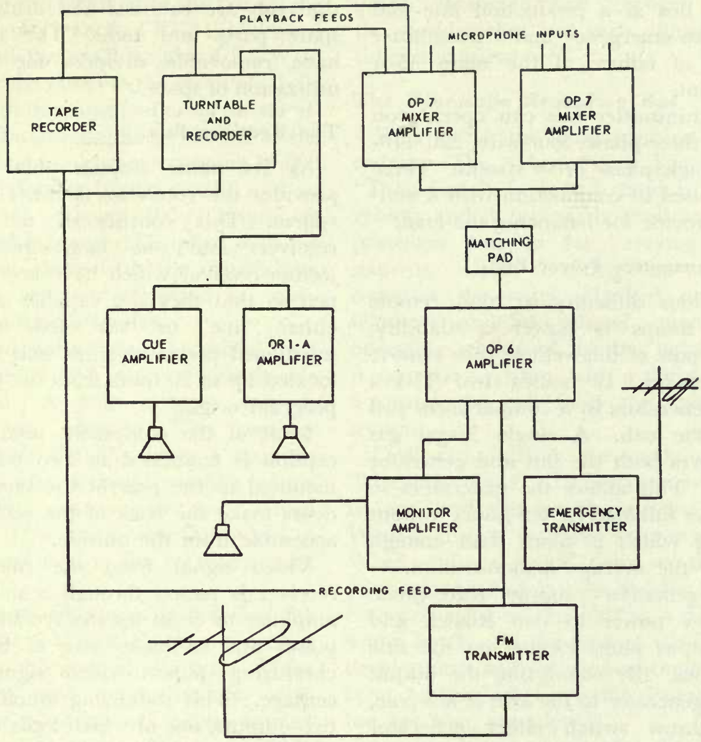

Fig. 3. Transmitter bus — audio distribution.

cessibility and ease of operation all microphone inputs, P.A. speaker feeds and intercommunication jacks are mounted on an aluminum strip which runs the width of the bus just below the cable reels. An RCA RT-11A rack-mounted (studio-type) tape recorder, a portable disc recorder-turntable, and a 30-w Brook amplifier with a bass reflex speaker used as a monitor system assure adequate audio facilities.

Figure 3 shows a simple block diagram of the audio layout. The OR-1A amplifier and its associated speaker serve as a public address or talk-back system when necessary.

The audio signal is transmitted to the receiver bus by a 45-w, phase-modulated, police transmitter which has been modified for high fidelity. A four-element yagi* is used as an antenna. A bridge off the program line feeding the transmitter feeds audio signal to the kine-recording van.

Each of the four vans is equipped with an FM transceiver on 163 mc which serves as an engineering line. Provision is made to operate these units from the bus battery as well as a-c so that communication can be maintained while the vehicles are in motion. An additional transceiver, on 173 mc, is provided in both the transmitter and

* Antenna array devised by Hidetsu Yagi in 1928. It consists of an active dipole and several short-circuited dipoles serving as directors and reflectors, to give a narrow beam.

receiver bus as a production line and also as an emergency audio transmitter in case of failure of the main 45-w equipment.

The transmitter bus can operate on either a three-phase, four-wire, 220/110-v or a single-phase 110-v system. Three variacs used in conjunction with a voltmeter provide for balancing the load.

The Transmitter Power Bus

A serious difficulty in most remote pickup setups is power availability. The purpose of this vehicle is to remove this problem. It houses two 15-kva motor generators in a compartment just aft of the cab. A single 55-gal gas tank serves both the bus and generator motors. This allows the generators to run under full load for ten hours without refueling which is more than enough time for the average demonstration.

The generators supply three-phase 208/110-v power to two Russell and Stoll output plugs located on the side of the bus. By connecting the output of each generator to the arm of a 3-pole, double-throw switch either generator can feed either plug or in emergency any one generator both plugs. The governor on the motor holds the output frequency within a half-cycle once it has been adjusted for a constant load. By operating the synchronizing generators with a long time-constant in the AFC circuit they lock in very well on 60 cycles.

Two 250-ft reels of four-wire #6 power cable are utilized to keep the line losses low while separating the vehicles to minimize the generator noise in the audio pickup. Two other reels carry additional camera cable, RG-11U coaxial cable for video feeds, and two-wire #10 cable for lighting and power extensions. The reels are accessible from the outside by the use of small ports in the side of the bus.

The rear compartment of this vehicle contains two work benches for equipment maintenance. Below the benches and the reels are cabinets and drawers for spare parts and tools. The drawers have removable dividers for greater utilization of space.

The Receiver Bus

As its name implies this vehicle provides the receiving facilities for the system. This consists of ten 16-in. receivers and one large-screen projection receiver which have been modified so that they are capable of being either "line" or "air" fed. As was mentioned previously, this unit may be located up to 20 miles from the point of program origin.

Most of the equipment used in reception is contained in two 6-ft racks mounted in the rear of the bus. Two doors make the back of the rack easily accessible from the outside.

Video signal from the microwave receiver is passed through a stabilizing amplifier to clean up the synchronizing pulses and to make sure of the synchronizing pulse-to-video signal percentage. This stabilizing amplifier has two outputs, one of which feeds a 12-in. monitor mounted alongside the rack and the other feeds two unity-gain distribution amplifiers having ten isolated outputs. The input and output of all equipment comes up on coaxial patch panels with parallel jacks for versatility and quick checking with an oscilloscope. In the present setup the output from one of the distribution amplifiers feeds a "Dumitter." The Dumitter is a closed circuit (nonradiating) transmitter whose function is to take audio and composite video signals and modulate a carrier on television channel 3. This modulated RF signal can then be sent over coaxial line to as many as 125 commercial receivers of 72-ohm input using a line distribution arrangement without modifying the receiver to a line-driven monitor. Small distribution boxes are provided with the Dumitter having one input and five outputs. By utilizing these boxes all ten receivers may be

placed up to 1500 ft from the bus by the outlay of only 3000 ft of RG11/U coaxial cable, and ten small lengths of RG59/U to couple the boxes to the receivers. To accomplish this same feat using the standard distribution amplifiers carried in the receiver bus would mean running 15,000 ft of special cable (single coaxial and an audio pair). Eleven 500-ft lengths of this special cable were supplied with the system but along with the distribution amplifiers are now relegated to emergency and special service.

Program audio signal is received on a single-channel FM receiver with double conversion. A four element yagi is used as an antenna. The receiver output feeds the Dumitter, a monitor amplifier, and a multi-winding transformer with one input and eleven outputs. This transformer provides a direct "line" feed to the receivers when desirable.

Three auto-transformers boosting the line voltage 5 v feed eleven a-c outlets located in the rear of the bus. These outlets are used in conjunction with 5,500 ft of two-wire #12 cable, carried in the receiver power bus, to provide power to the receivers. The auto-transformers make up for the losses incurred by long power runs.

The Receiver Power Bus

The layout of this vehicle is quite similar to that of the transmitter power bus. The main difference is that it has one 15-kva motor generator which allows for a larger rear compartment. This compartment contains ten reels which hold 500 ft of microwave cable, 250 ft of four-wire #6 power cable, 5,500 ft of special receiver cable, 5,500 ft of two-wire #12 receiver power cable, 2,000 ft of RG11/U coaxial cable, and 1,500 ft of RG59/U coaxial cable. This compartment also houses two workbenches. One of these is set up as a receiver test bench complete with television sweep generator, sweep calibrator, vacuum tube voltmeter and oscillograph. Cabinets and drawers, below the workbenches and reels, house spare tubes and parts.

The Kinescope Recording Bus

This unit is the latest addition to the system. The vehicle is a Fagoil-type "Twin Coach." It is a standard Army vehicle and is ordinarily used as a 36-passenger bus or for carrying litter patients. Upon receiving this unit we removed the seats, blanked out the windows and in general, made the operating section of the bus light-tight. A plywood partition with a sliding door separates the cab from the operating section.

Ordinarily, prints are made of the "kine-recordings" so negative recording is used and the sound recorded on a Westrex 16mm portable tape recorder. When only a single print is desired positive recording is used and the sound recorded right on the film by a Maurer sound head. At the time of writing no development and printing methods have been established since the installation has not been completed.

As mentioned previously, the iconoscope film chain is now located in this vehicle. The chain has been laid out in such a way that one man can handle the operation without leaving his operating chair.

The bus contains cabinets for film and spare parts storage. Two reels contain enough cable to locate this vehicle up to 150 ft from the transmitter bus. The reels are accessible from the outside of the vehicle.

Employment of the System

After a period of testing and break-in the unit embarked on its first mission 18 February 1952. This mission was to provide television facilities for the Army Field Force Commanders' Preventive Maintenance Course held at Aberdeen Proving Ground, Maryland. Upon arrival demonstrations were set up and a weekly schedule arranged. Four of

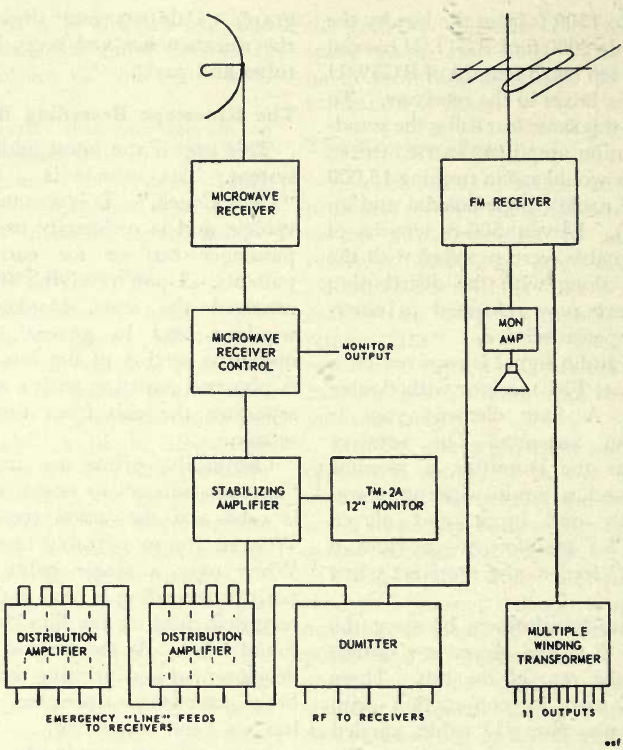

Fig. 4. Receiver bus — audio-video distribution.

these shows were studio presentations and covered preventive maintenance in the various branches of service. The other two were remotes of which more shall be said later.

For the studio presentations a theater was utilized. The transmitter bus was used as a control room. Ample commercial power was available so the motor generators were not needed. Camera cables, microphone cables, talkback and PL lines, and coaxial cable feeds for stage monitors were run into the rear of the building. The theater had only been used for motion pictures and therefore had very poor lighting facilities. Scoops and spots were obtained to supplement the portable lighting equipment carried by the system. Everything was installed on a semi-permanent basis so that if a remote pickup was contemplated the only thing necessary was to disconnect the cables from the van, load in the cameras and be off.

The receiver bus was parked close by with five video-audio lines to two classrooms. The large screen projection system was installed in the front of the classroom flanked on either side by a 16 in. receiver for students whose viewing angle to the large screen was too acute.

Each week the officer-students answered a questionnaire after seeing the foregoing productions. Results showed that the utilization of television as a training aid was highly successful.

The most important of the remote pickup programs was entitled "The Video War Room." This program

taxed the engineering facilities of the system to the utmost. The production portrayed tactical television as it might function in the future. Cameras were concealed in a barn loft observation post, and by utilizing some eighty enlisted men as friendly and aggressor troops, along with tanks and planted charges, it realistically demonstrated how television front line cameras could send information back to division level where it could be analyzed by the Division Commanding General and his staff and acted on accordingly.

While this production fulfilled the unit's primary mission of stimulating thinking about the tactical use of television, it also emphasized to the engineer the need for simple, compact portable equipment with a low power drain.

In May 1952 the unit participated in several exhibitions including the Armed Forces Day Exhibition at Bolling Field, Washington, D.C. The unit then departed for West Point, where it provided television facilities and was on exhibition for June Week.

Closed-Circuit Television Demonstration at NOL

The use of short-range closed-circuit television for scientific and plant operation demonstrations is attracting wide attention in many areas today.

The 72nd Semiannual Convention of the SMPTE held one meeting in the U.S. Naval Ordnance Laboratory. Since security restrictions and time would not have permitted the members to visit the large wind tunnel facilities, a telecast was arranged through the medium of a closed-circuit television system provided by the Army Signal Corps.

The audience of approximately 150 persons was addressed by Dr. H. H. Kurzweg, Chief of the Aeroballistics Research Division, in the NOL auditorium.* Then the program was switched to the wind tunnel building about one-half mile away. The picture and sound for the telecast from the wind tunnel were transmitted over an interconnecting relay link. The picture was viewed on theater projector system and several standard television receivers in the auditorium. Sound was heard through the auditorium sound-reinforcing system and was recorded through the plant sound-recording system.

A communication system was set up to interconnect the wind tunnel program director, link transmission truck, link receiver truck, auditorium moderator and the recording facility. Included in the system were extensions to dial phones, special telephone lines and radio transceivers where telephone lines were not feasible.

Through television, the audience saw and heard actual wind tunnel operations explained by the Chief of the Design and Operations Division, J. R. Lightfoot. Schematic diagrams were used to demonstrate the essential components of the large supersonic wind tunnels for research and development testing at equivalent air speeds up to five times the speed of sound and of the similar hypersonic tunnel at speeds up to ten times that of sound.

The working section of the large Tunnel 1 was kept open to show the nozzle contour and the missile model positioned on its support. Tunnel 2, also a 40 × 40 cm tunnel and identical

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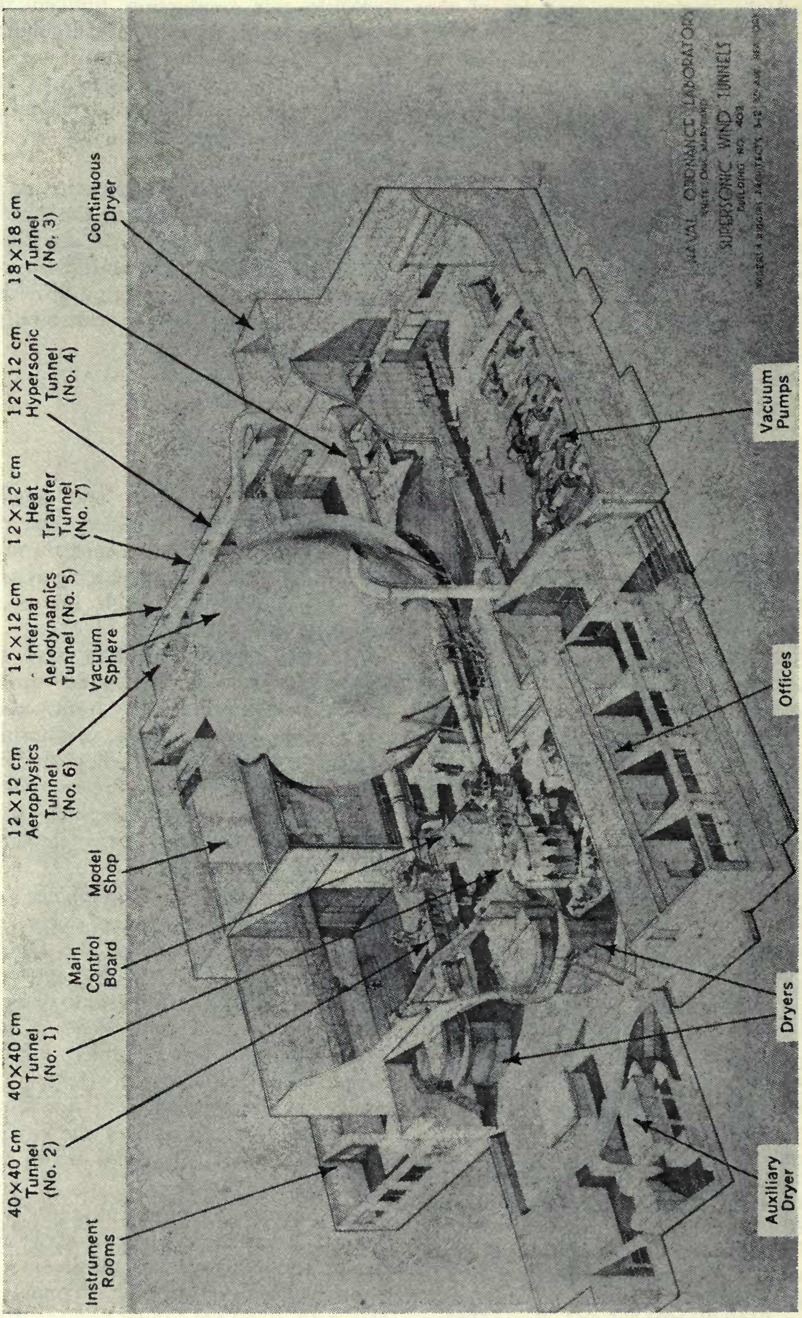
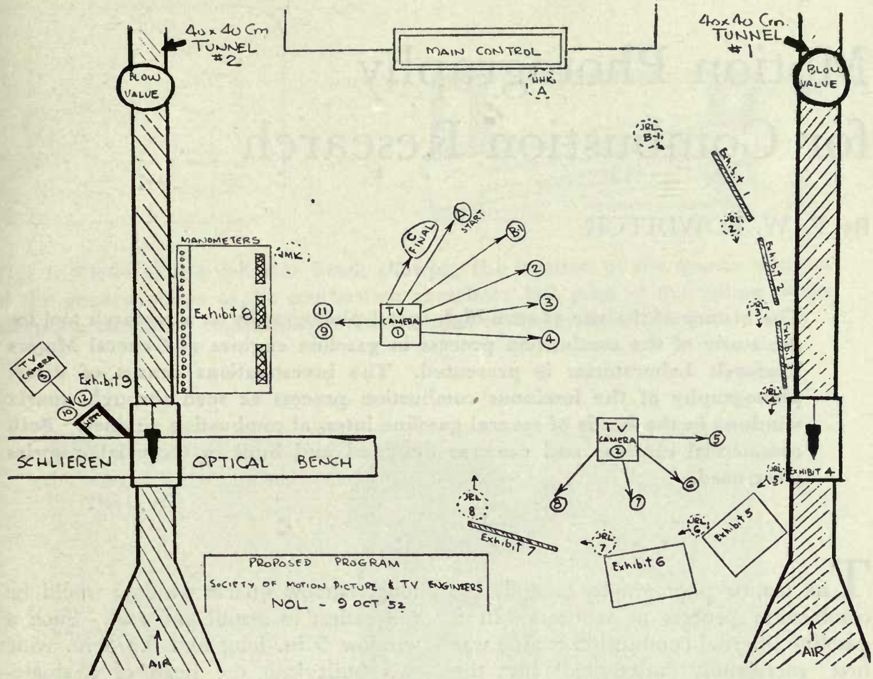
Supplied by Mary T. Kanagy, Public Information Officer, U.S. Naval Ordnance Laboratory, White Oak, Silver Spring 19, Md.

* For auditorium details see D. Max Beard and A. M. Erickson, "Auditorium specifically designed for technical meetings," *Jour. SMPTE, 59:* 205–211, Sept. 1952.


Instrument Rooms
40×40 cm Tunnel (No. 2)
40×40 cm Tunnel (No. 1)
Main Control Board
Model Shop
12×12 cm Aerophysics Tunnel (No. 6)
Vacuum Sphere
12×12 cm Internal Aerodynamics Tunnel (No. 5)
12×12 cm Heat Transfer Tunnel (No. 7)
12×12 cm Hypersonic Tunnel (No. 4)
18×18 cm Tunnel (No. 3)
Continuous Dryer
Vacuum Pumps
Offices
Dryers
Auxiliary Dryer
NAVAL ORDNANCE LABORATORY
SUPERSONIC WIND TUNNELS



in most respects to Tunnel 1, had a similar model mounted in its working section and was actually operated.

After the test models of missiles had been displayed and basic instruments for measuring pressures, forces, and temperatures demonstrated, air was blown through Tunnel 2 at supersonic speed and a schlieren picture of the shock waves about the missile model was picked up on television camera 3 and telecast to the auditorium. At the same time the audience observed pressure-measuring instruments in actual use and saw much of the operation which would have been difficult to demonstrate to a large group of visitors even had a trip to the tunnels been possible.

The telecast concluded with a statement of planned improvements and future modernization of the plant, instrumentation and scientific techniques.

Motion Photography for Combustion Research

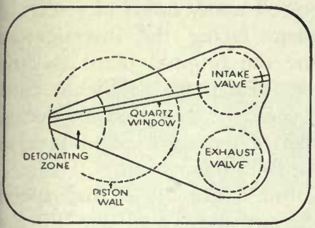
By F. W. BOWDITCH

The history of the use of semi-high-speed photography as a research tool for the study of the combustion process in gasoline engines at General Motors Research Laboratories is presented. The investigations consist of direct photography of the luminous combustion process as seen through quartz windows in the heads of several gasoline internal combustion engines. Both commercial cameras and cameras designed and built in these laboratories were used.

THE USE OF photography to study the combustion process as it occurs in a gasoline internal combustion engine was first successfully attempted[1] at the Research Laboratories Division of General Motors Corp. in 1930. Until then practically all information known about gasoline engine combustion had been obtained from pressure-time cards and from sampling valve studies. The results of the pressure card and sampling valve studies indicated that these methods alone could not completely describe the physical aspects of the combustion process.

It was decided that by taking photographs of the combustion process through a quartz window mounted in the head of a single-cylinder engine a physical picture of the combustion process could be obtained. Since the use of a quartz window in the head of an engine was entirely new, it was decided that a long, narrow quartz window would be the easiest to install and seal. Such a window 5 in. long and 0.375 in. wide was built into the head of a single-cylinder engine in a manner shown in Fig. 1. A film drum was mounted over the engine, with the axis of the cylinder parallel to the major axis of the quartz window, and a Meyer Plasmat $f/1.5$ lens was used to focus the quartz window on the drum. The drum and a focal-plane type shutter were driven from the camshaft of the engine in a direction normal to the direction of flame travel in the engine. The engine and camera equipment are shown in Fig. 2. Eastman Portrait Panchromatic cut film was wrapped around the drum, sufficient circumferential drum space for the film being provided so that enough film for one explosion could be used at a time. Examples of knocking and nonknocking type of flame record obtained are the upper parts of Fig. 3. Photographs of the ignition sparks appear at A and of timing sparks at B, 20° later. The flame photographs were taken with the film moving toward the left and the

Presented on October 9, 1952, at the Society's Convention at Washington, D.C., by F. W. Bowditch, Research Laboratories Division, General Motors Corp., Detroit 2, Mich.



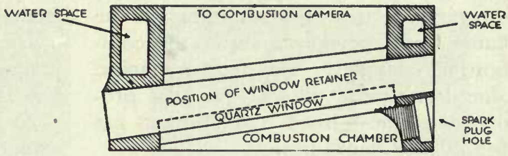


Fig. 1. Views of the cylinder head, showing the location of the quartz window and the general shape of the combustion chamber; left, plan of the ceiling of the combustion chamber; right, longitudinal section of the cylinder head.

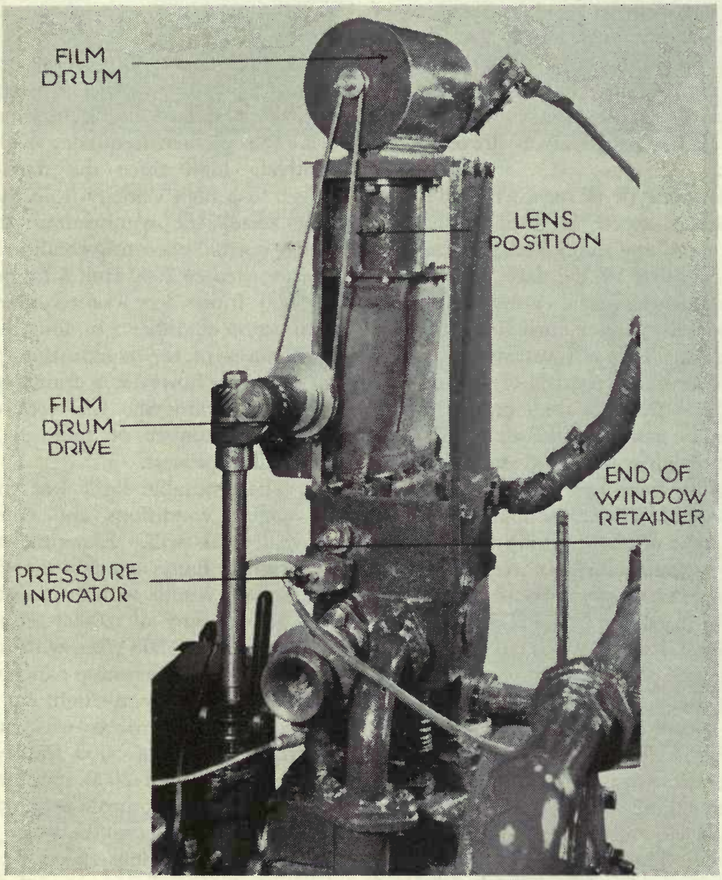


Fig. 2. The first combustion camera mounted upon the engine.

flame moving from the bottom to the top of the photographs. The upper sloping edge of the light portion was therefore a time-distance plot of the flame front movement across the combustion chamber. The region marked afterglow in the photographs was produced by the burned but luminous gas behind the flame front.

It was from these researches that it was definitely determined that normal combustion in a gasoline engine was initiated at a single point — the spark discharge — and spread from this point like a grass fire at a rate which could be determined from the slope of the pictures similar to the flame records of Fig. 3. It was also found that during the combustion process there is a relatively narrow zone in which all of the combustion process takes place and which moves progressively through the charge.

From this type of record it was found that flame speed is proportional to engine speed and that knock in a gasoline engine consists of the last part of the charge burning at a rate many times that occurring under normal combustion conditions. This is illustrated by comparing the flame records of Fig. 3. So it was that the first photographs of the burning of gasoline and air in a spark ignition engine furnished many of the basic facts which are now used daily in the design of better automobile engines.

This type of photography was limited, however, particularly in regard to determining the shape, structure and movements of the flame fronts and the nature of knock. In particular it was hoped that flame photographs would supply information regarding the effect of engine speed, chamber shape, fuel types, etc., on the rate of flame travel. These considerations led to the development of another engine which allowed an unrestricted view of the entire combustion chamber. The head and cylinder block are shown in Fig. 4. The problem of sealing the quartz window in the head frame required many hours of research. The problem facing the investigators at the time the original plans for the engine were drawn up was what type of camera could best be used for taking photographs of the combustion process through the full quartz head.

At this time a number of high-speed camera designs were available in the literature; however, careful consideration of the following aspects of the photographic problem showed that many of these cameras would be unsuitable:

1. The subject to be photographed was self-luminous; that is, the light was emitted from the flames themselves. This imposed a severe limitation upon camera design from an exposure standpoint and ruled out those cameras which depended upon a separate high intensity source of illumination.

2. The picture frequency had to be relatively high since the flame front moved at a high velocity from the spark plug across the combustion chamber. Under normal operating conditions at an engine speed of 2000 rpm a frame speed of 5000 frame/sec was required in a combustion chamber 5 in. long to obtain 20 pictures of the combustion process. At 400 rpm, however, a frame speed of only 1000 frame/sec was required for the same number of pictures of the combustion process.

3. The available light was fixed by the engine conditions and could not be varied at will. Experiments with the original flame camera showed that satisfactory results could be obtained with an exposure of 0.0002 sec and an engine speed of 1200 rpm, with an $f/1.5$ lens using a hypersensitive panchromatic film. Consequently, the light emitted by the combustion process was sufficient for frame speeds of 5000 frame/sec at an engine speed of 2000 rpm provided the duration of exposure was comparable with the time interval between frames and provided the lens speed was $f/1.5$ or greater throughout most of the exposure. In order to fulfill these condi-

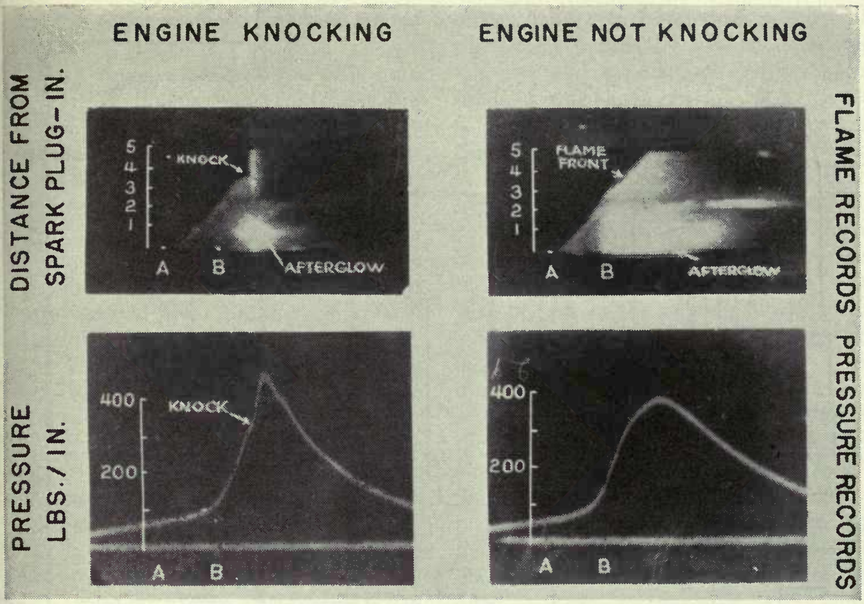


Fig. 3. Pictures show the effect of knock on the flame and pressure records; A, time of ignition; B, 20 deg after ignition.

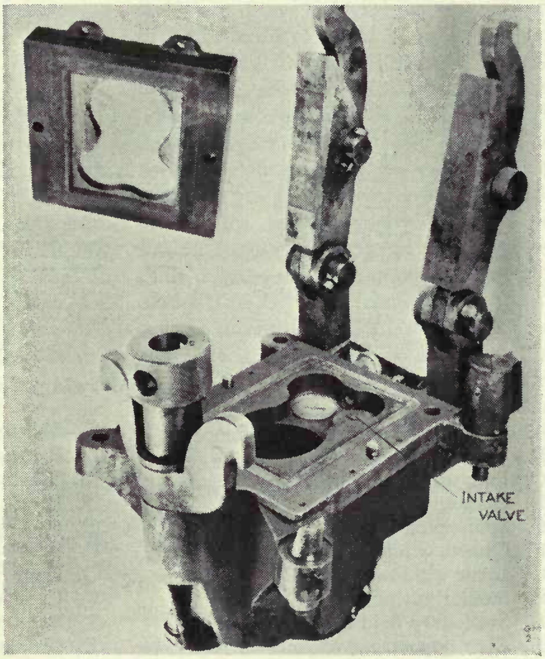


Fig. 4. Photograph of the head and block of the full-view quartz window L-head engine.

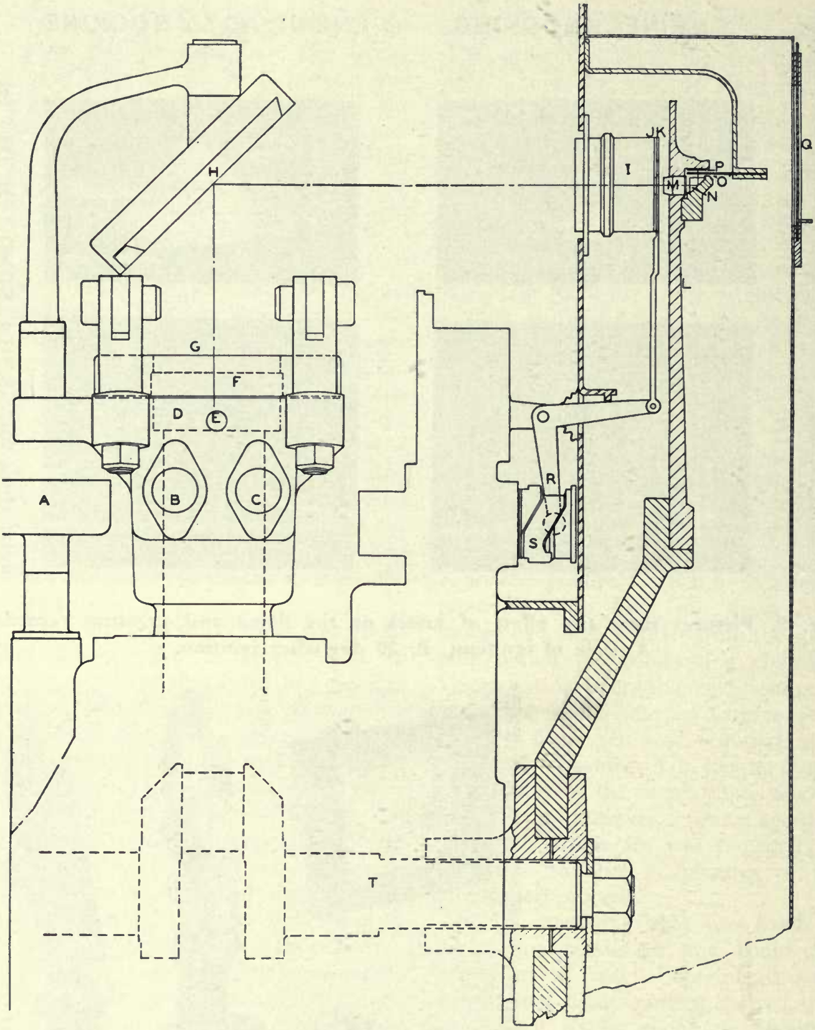


Fig. 5. Schematic drawing of camera.

A. Ignition breaker
B. Intake port
C. Exhaust port
D. Combustion chamber
E. Spark plug hole
F. Quartz window
G. Invar window frame
H. Stellite mirror
I. Stationary field lens
J. Lens stop
K. Shutter
L. Rotating disk
M. Moving lens
N. Prism
O. Focal plane shutter
P. Film
Q. Door in light-tight housing
R. Cam follower which actuates shutter
S. Shutter cam
T. Crankshaft

tions the film and image had to be moved together.

4. In order to obtain the minimum amount of blurring due to the rapid movement of the combustion process, it was necessary to utilize the shortest possible exposure time. Since light intensity could not be varied at will, the other alternative was to maintain a maximum lens speed during the entire exposure. This type of operation is approximated with the use of a focal plane shutter.

5. The picture could not be so small as to lose the details of the combustion process. A standard 16mm frame was chosen as the smallest suitable picture size. 16mm pictures taken at 5000 frame/sec require a minimum film speed of 38 meters per second.

6. In order to make full use of the flame pictures the angular position of the crankshaft during the exposure had to be known. Similarly, the gas pressure in the combustion chamber had to be known at the same angle and in the same explosion for each picture.

7. Simplicity of construction was an important consideration that need not be expanded upon here.

Of the optical systems available at the time, the system suggested by Wedmore[2] seemed more nearly to fulfill the qualifications than any other. A camera incorporating these principles was built into the flywheel of the engine and is shown schematically in Fig. 5. Light from the combustion chamber, D, passed through the quartz window, F, and was reflected by the stellite mirror, H, into a stationary field lens, I, (a Zeiss Opal Tessar). The principal plane of the field lens was in the combustion chamber. The beam of parallel rays formed by the field lens passed through each of a series of small lenses, M, as they were moved through this beam of light by a large circular disc attached to the crankshaft and rotated in a plane perpendicular to the plane of the paper. Light from the series of lenses, M, was reflected by a corresponding number of right-angle prisms, N, also mounted on the disc and located one behind each small lens as shown in Fig. 5. Images of the flames inside the combustion chamber were formed upon the film, P, which was held against the inside surface of the rim of the disc by centrifugal force. With such a system, the image of a stationary object in the combustion chamber remains at rest with respect to the moving film (except for a slight twisting motion) despite the motion of the 30 small lenses. The duration of exposure of each picture was controlled by varying the width of the stationary aperture, O, which was close to the film and acted like a focal-plane shutter. Another shutter, K, was provided with the necessary actuating mechanism so that exposure would take place through only one revolution of the disc.

The moving lenses were $f/2$ motion picture camera objectives purchased from the Eastman Kodak Co. The focal lengths were closely matched, but slight differences could be compensated for by individual adjustment of the position of each lens in the large disc. The lenses were spaced 2.4 crankshaft degrees apart, therefore 5000 frame/sec could be obtained at an engine speed of 2000 rpm and adequate exposure obtained by adjusting the focal plane shutter to give an exposure of 2.2 crankshaft degrees for each picture or $91\frac{2}{3}\%$ of the time between frames.

It is interesting in this connection to calculate the amount of light lost in this optical system. The stellite mirror, H, Fig. 5, scattered about one-half the light incident upon it. The amount of light lost by Fresnel reflections at the glass-air surfaces of the rest of the optical system may be approximated from the equation

$$t = \left[1 - \frac{(n-1)^2}{(n+1)^2}\right]^k$$

where t is the total transmittance if

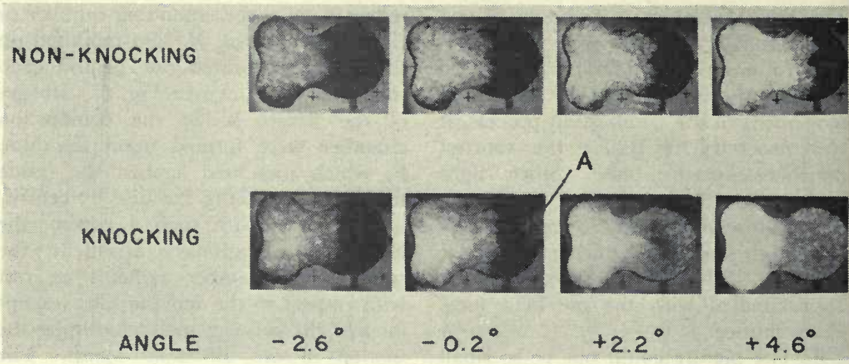


Fig. 6. Full-view flame pictures which distinguish between knocking and non-knocking combustion; four frames on left are before top dead center, and four frames on right are after top dead center.

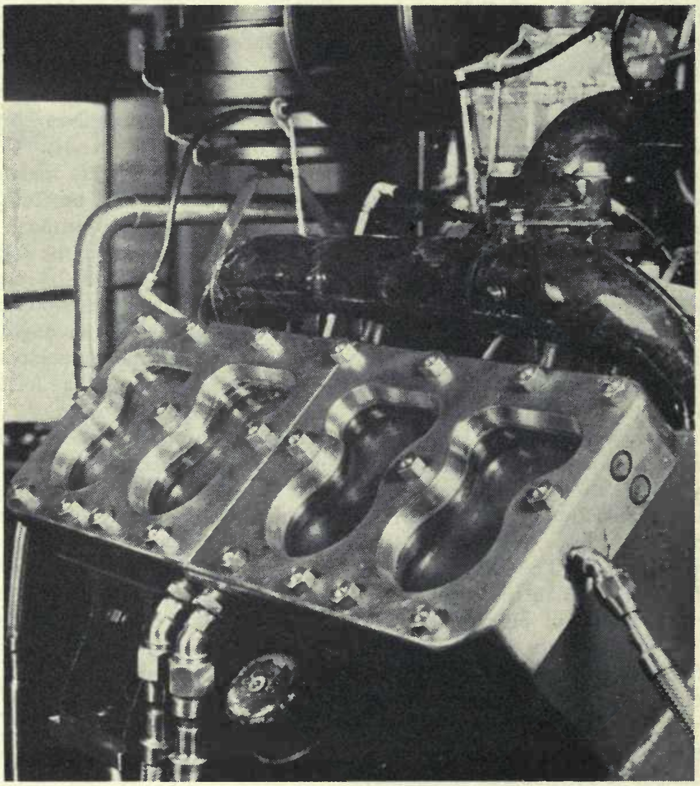


Fig. 7. 1939 Cadillac engine with quartz-window heads on left bank.

absorption is neglected, n is the refractive index of the optical glass, and k is the number of glass-air surfaces. Since the refractive indexes of optical glass in common use lie between 1.5 and 1.7, the average value of $(n - 1)^2/(n + 1)^2$ is about 5% and the transmittance can be computed with reasonable accuracy[3] as $t = (0.95)^k$.

The high-speed camera optical system consisted of 16 glass-air surfaces since both the field lens and the moving lenses were multicomponent lenses. The amount of transmitted light, therefore, through the lens system and prisms amounted to 44% of the incident light not considering that lost at the stellite mirror. Therefore, since about 50% of the light was lost at the stellite mirror, the approximate total transmitted light was about 22% of the incident light. If all the glass-air surfaces had been coated, as is now current practice, the approximate total transmittance would have been about twice as much or 44%. The present-day Eastman High-Speed Camera Model III, a rotating-prism type camera, having a coated Ektar lens and an uncoated prism can be used without the large stellite mirror mounted over the engine head and the transmittance of this optical system is approximately 83%. The older ERPI Camera (Electrical Research Products, Inc.) with uncoated optics, another rotating-prism type of camera, without the engine stellite mirror had a transmittance of about 73%.

Since the ERPI exposure time amounted to about 25% of the time between frames and the engine camera to about 90% of the time between frames, the total amount of light reaching the film per frame at the same frame speed in the two cameras was about the same due to the total transmittance difference of the two cameras. Experimentation with an ERPI camera since the engine camera was built has shown that even though the flame front moved about three-and-one-half times as far per exposure with the engine camera as it did with the ERPI camera, photographs of about equal definition were obtained with the two cameras. This apparent anomaly may be at least partially explained by the distortion of the images in the rotating-prism cameras due to the motion of the prisms.

Returning to the combustion photographs obtained with the engine high-speed camera, unrestricted views of nonknocking and knocking explosions were taken. The knocking explosion pictures revealed in a most striking manner the occurrence of spontaneous ignition in sections of the unburned charge well ahead of, and completely separated from, the advancing flame front. Figure 6 illustrates this difference between normal or nonknocking combustion and knocking combustion.

From similar pictures and corresponding pressure records Drs. Withrow and Rassweiler[4] were able to sort out pressure changes due to combustion from those due to piston motion on the pressure records and found very important relations between per cent of pressure rise and per cent of fuel-air mixture burned. They were also able to determine the effects of changes in mixture ratio, spark position and throttle opening upon the combustion process — all very important to the operation of our modern automobile engines.

In 1939 interest was revived in a combustion phenomenon known as "after-running" (tendency for engines to continue running at very low speeds after ignition has been shut off). At this time a 1939 V-8 Cadillac engine was made available to these Laboratories and quartz windows were mounted on the left bank affording an unrestricted view of the combustion chambers in these four cylinders. This engine with the quartz windows in place is shown in Fig. 7. This engine may be familiar to the reader since it was later exhibited at the New York World's Fair.

In this investigation it was necessary

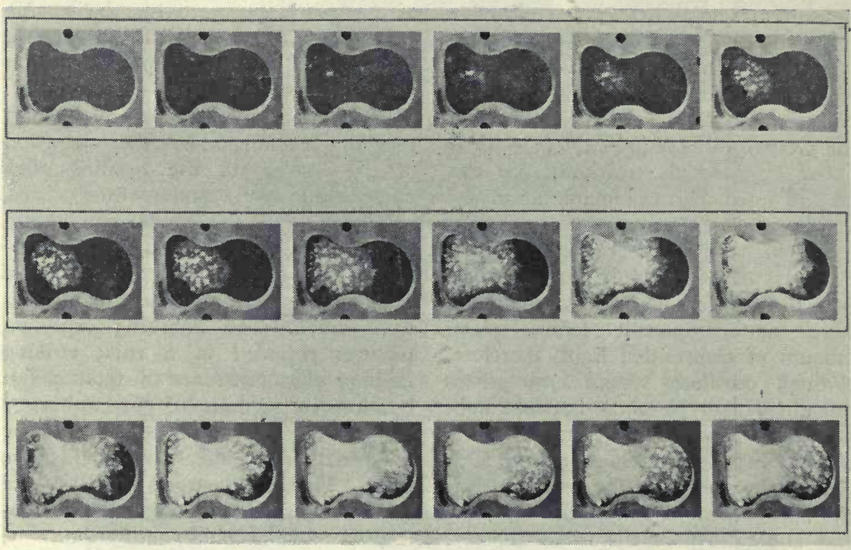


Fig. 8. Flame pictures of combustion in cylinder four of Cadillac window engine during after-running; engine speed 260 rpm; throttle partially open; ignition spark cut off; compression ratio 5:1; 60-octane secondary reference fuel; intake at top and exhaust at bottom of each picture; 18 successive frames taken at rate of 1140 frames per second.

to obtain photographs of *consecutive* explosions as they occurred in the engine. Therefore it was not possible to use the high-speed camera principles as outlined by Wedmore and used in the previous window engine since the old engine camera was capable of taking pictures of only one explosion. The ERPI high-speed camera was used. In this camera the field lens focuses the image on the continuously moving 16mm film. Between the lens and the film a glass plate, or two-sided prism, is rotated in such a way that the image is made to move with film. In order to assure complete synchronization of the film and the image, a single motor is used to drive both the film and the prism. A complete discussion of the operation of this camera may be found in the literature.[5]

Eastman Kodak Super XX film and its standard developing procedure were used. Speeds were about 1150 frame/sec and engine speeds were approximately 260 rpm. The engine ignition system was shut off. Photographs were taken of two adjoining combustion chambers simultaneously with no effort being made to determine the crankshaft angular position for each photograph. Figure 8 is an example of the photographs obtained for one explosion in one of the combustion chambers. This investigation revealed the important fact that "after-running" was not due to hot spots in the combustion chamber since consecutive explosions showed that combustion was never initiated at the same point in the combustion chamber in any two explosions. The exact mechanism of this phenomenon is still not known.

The investigation of autoignition (ignition by means other than the spark plug discharge) was reopened in 1943. At that time interest in the problem was quite high because of a general occur-

rence of field complaints. For this investigation the original full-view window engine (see Fig. 4) without the camera attachments was used. The ERPI camera was used again with 16mm Super XX motion picture film since photographs of consecutive explosions were again required.

It was necessary in portions of this investigation that the angular position of the crankshaft for each photograph be known since the photographs were to be used in connection with pressure card data. A double-lobed cam was used on the distributor so that the spark plug (which was in the field of the camera) would fire twice, once to initiate combustion and again 90 crank-angle degrees later for a timing mark. These spark discharges did not always appear on the film because they would sometimes occur entirely during the two-thirds of the time the film was not being exposed. By using the built-in ERPI timer and those spark discharges which were available, it was possible to determine the average time in crank-angle degrees per frame and so determine the angular position for each photograph. Similar calculations were made on the time axis of the pressure records so that the photographs and pressure records could be related. It is interesting to note that the speed of the engine could be found more accurately from the flame photographs than with the available engine instrumentation due to the electrical timer built into the ERPI.

For orientation purposes the metal frame around the quartz window was illuminated with 120-w photoflood lamps. These lamps were used at shallow angles of incidence to the head of the engine so that the combustion chamber itself was not illuminated. This frame outline on each photograph provided the necessary reference points for the orientation of the random centers of ignition which occur during autoignition.

In this autoignition investigation various types of engine deposits were accumulated with a full metal head on the engine. The engine was then stopped and the quartz head substituted for the metal one. Pictures of the combustion process in the presence of the deposits were taken shortly after the engine was restarted. Ordinarily the engine with the quartz head could be run for only short periods of time with deposits in the combustion chamber since the deposits became detached from the combustion chamber walls and were deposited on the quartz window. By taking photographs of consecutive explosions as they occurred in the presence of various deposits, some very important effects of combustion chamber deposits upon the combustion process were determined.

Interest was again revived in the subject of autoignition in 1951 since autoignition rather than knock became one of the most important considerations in attempting to increase the performance of automobile engines. The original full-quartz-head window engine, now 21 years old, was again used at the beginning of this investigation which is now in progress.

Four changes have been made in the procedure used in 1943. The first was the substitution of an Eastman Model III High-Speed Camera for the older ERPI camera. The basic principles of operation of the two cameras are the same but improved methods of operation are incorporated in the newer camera. A complete description of this camera may be found in the literature.[6]

Second, since stiffening blocks had been added to the top surface of the window frame, the angle of incidence of the illumination from the flood lamps used to light up the frame around the quartz window had to be increased. In so doing some of this light illuminated portions of the combustion chamber making definition of the combustion process in these areas difficult. There-

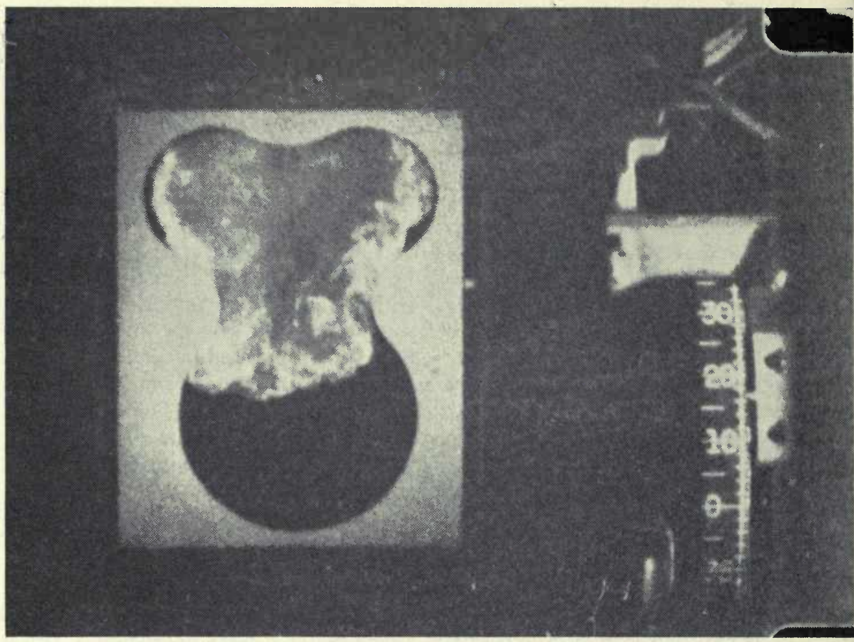


Fig. 9. 16mm frame showing the flywheel at the right and the fluorescent window frame.

fore, the top of the window frame was painted with blue fluorescent sign paint and illuminated with ultraviolet light from three General Electric 100-w E-H4 projector flood lamps operated on direct current using filters similar to Corning filter color specification 739 which confined most of the illumination to ultraviolet wavelengths. This method gave sufficient visible light from the window frame but did not affect the pictures of the combustion process.

The third major change from previous operating procedure was the use of Eastman Kodak Linagraph Pan 16mm film in place of Eastman Kodak Super XX film. This was done because of the exceptional blue sensitivity of this new film and the predominance of blue light given off by the combustion process allowing shorter exposure times to be used.

The fourth and perhaps most important change in procedure was the method used to determine the angular position of the crankshaft at which each picture was taken. This was done by replacing the $f/2.7$, 63-mm focal-length lens with which the camera was equipped with an $f/1.9$, 25-mm focal-length lens. The shorter focal-length lens provided a sufficiently great depth of focus so that when the combustion chamber of the engine was in focus the flywheel of the engine which was about seven inches further from the camera than the combustion chamber remained well enough in focus so that the degree divisions on the flywheel could readily be seen. Even though the shorter focal-length lens reduced definition, the photographs were sufficient for this study. The rim of the flywheel was painted a dull black and the degree divisions and numbers white. At frame speeds of 2000 frame/

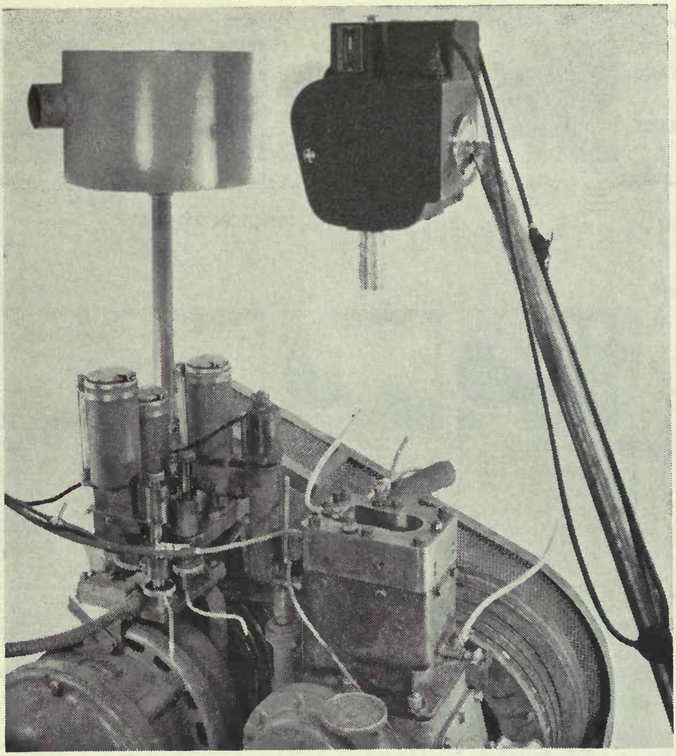


Fig. 10. Eastman Camera and CFR L-head engine fitted with quartz window.

sec and flywheel rim velocities of about 47 ft/sec the numbers and degree division marks were sufficiently clear that readings to the nearest one-half crankshaft degrees could be made on each picture. An example of the results obtained by using the fluorescent frame, the Linagraph Pan film and the short focal-length lens is shown in Fig. 9.

When the opportunity presented itself in 1951 a newer engine more nearly like the modern automobile engine was equipped with a quartz head (Fig. 10). The work on autoignition was transferred to this engine with three alterations in the photographic procedure. First, since the head of the engine was unobstructed, photoflood lamps could be used at shallow angles of incidence to illuminate the quartz frame. Second, the flywheel division marks were made narrower and longer allowing the crankshaft angular position for each frame to be determined within 0.1°. The third change in photographic procedure was brought about by the desire to obtain both motion pictures of the combustion process and, simultaneously, oscilloscope pictures of the pressure records of the combustion processes. A Fairchild oscilloscope camera was used to take the oscilloscope pictures and, in order to relate the pressure records to the corresponding engine combustion process, both a small incandescent lamp in the oscilloscope camera and a 40-w incandescent lamp in the field of view of the high-speed camera were flashed simultaneously. By having one explosion related, the remainder of the two films

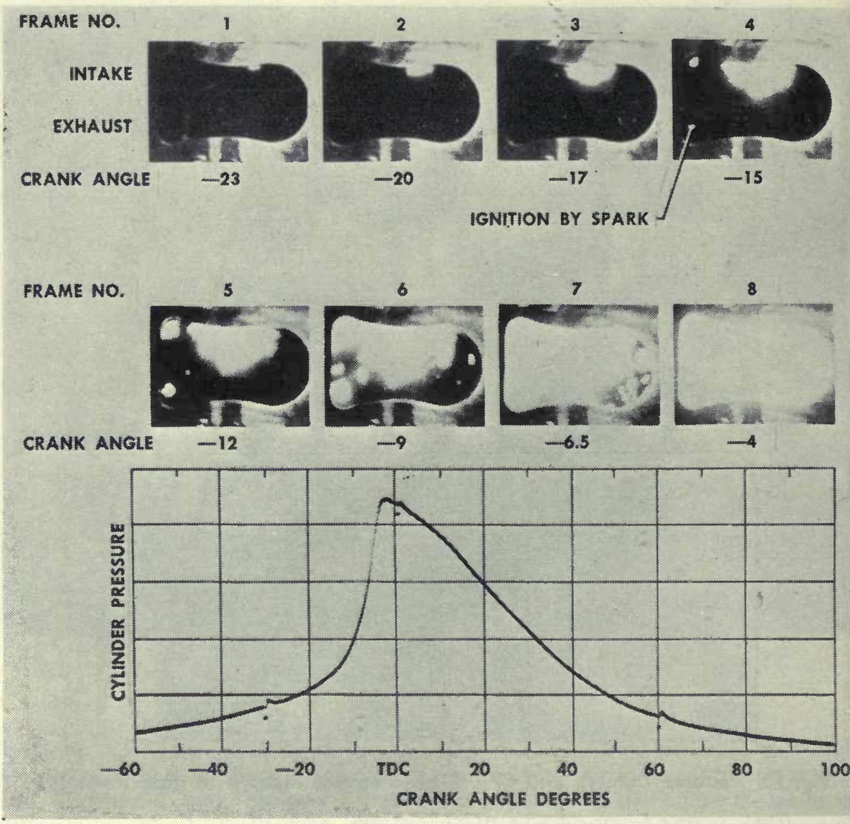


Fig. 11. Flame pictures and corresponding pressure card of preigniting explosion; engine speed 900 rpm; throttle fully open; spark advance 16 deg before top dead center; air-fuel ratio 13:1; compression ratio 6.8:1; 70-octane number reference fuel.

could be correlated readily. Figure 11 illustrates the type of record obtained by this process. This engine and photographic procedure is being used at the present time as a tool in the continuing research on our modern automobile engine.

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Accuracy Limitations on High-Speed Metric Photography

By AMY E. GRIFFIN and ELMER E. GREEN

Parameter limits in high-speed camera design and physical characteristics of photographic images limit the assessment accuracy of high-speed metric film records. The errors in film measurements range from 2 to 75 microns. Proper design of field instrumentation is required to minimize effects of reading errors in a measurement system for ballistic data.

Uses of Metric Cameras

The measurement system on the ground ranges at the U.S. Naval Ordnance Test Station, Inyokern (NOTS), was designed primarily to obtain ballistic data on rockets and guided missiles. High-speed photography, which is here defined as photography at more than 500 frame/sec, is a useful tool for studying missile flight phenomena such as flame characteristics but is seldom applicable to the study of ballistic parameters which are derived from missile trajectory and attitude data. High-speed cameras are not useful for these purposes because, in general, their accuracy limitations are too severe to permit their use at their high frame rates as metric instruments, i.e. instruments from which data such as velocity, acceleration and direction of motion (which are usually obtained by differencing successive position determinations) can be obtained.

If an unsuccessful missile flight is caused by factors inducing vibrations or moments resulting in instability, the first photographic evidence of this may be some physical change in the missile such as the breaking of a stabilizing fin. To pinpoint the time of this occurrence photographically to desired accuracy may require frame speeds of 1000 per sec or higher, but a mere determination of the moment of failure is inadequate for flight analysis. In addition to knowing the exact time of failure it is necessary to study closely the behavior of the missile previous to this time to determine whether the fin was substandard or whether the failure was caused by unexpected stresses on the fin. If the latter is the case, data are required to determine whether the unexpected stresses were caused by aerodynamic forces larger than anticipated or by inability of the missile to achieve flight stability under the anticipated conditions.

Presented by Amy E. Griffin on October 9, 1952, at the Society's Convention at Washington, D.C., by Amy E. Griffin and Elmer E. Green, Assessment Div., Data Reduction Branch, U.S. Naval Ordnance Test Station, Inyokern, China Lake, Calif.

Table I

Camera type	Shutter type	f/stop	Focal length, in.	Frame speed, expos./sec	Frame size, mm	Expos. time, msec	Film movement during expos., mm
Askania Cine-Theodolite	Venetian blind	6.3	24	4	37×27	6	None
		8.0	6	32	25×18	10	None
Mitchell	Rotating sector	8.0	48	64	25×18	5	
		25 with 21 filter	120	48	25×18	7	
Bowen Ribbon Frame	Revolving drum slit	5.6	10	30 to 180	133×24 to 133×4	0.1 to 0.03	0.068 to 0.023
General Radio	None (Edgerton Flash)	2.8	4	1000 to 7000	26×8 to 26×4	0.001	0.009
Fastax	Rotating prism	2.0	2	2500 to 4000	25×9 11×4	0.10 to 0.06	0.04* to 0.06

* Compensation by rotation of prism eliminates most effects of film movement.

The photographically obtainable data which are required to determine the cause of failure are the missile velocity, acceleration, direction of motion and attitude. From the difference between the attitude of the missile and its direction of motion can be determined the direction in which aerodynamic forces are applied to the fins. From the missile velocity and acceleration can be determined the magnitude of the forces. The direction of the force may be needed to an accuracy of $\pm 0.1°$ or better. The acceleration may be required to an accuracy of ± 1 G.

To obtain free-flight data with the above accuracy at rates of 1000 frame/sec would require impossible accuracies in position determinations. Random errors of ± 0.00001 ft in position would result in an error of ± 1 G in accelerations obtained by differencing of position data from successive frames.

Using specially designed cameras, it is often possible to hold random errors in missile position determinations to approximately ± 0.04 ft. When position determinations are held to this accuracy, frame rates in the order of 20 per sec result in acceleration accuracies of ± 1 G. If long focal length lenses are used with these special cameras or if the cameras can be placed close to the flight line, random missile position errors in the order of ± 0.001 ft can be obtained. Frame rates of 90 per sec can be used with this position accuracy to obtain ± 1 G acceleration accuracy. This accuracy, however, can be achieved only with such cameras as the Bowen Ribbon Frame camera and then only if the film can be read to an accuracy of ± 2 microns.

Camera Parameters

Some of the cameras in use at NOTS are standard high-speed machines but others such as the Bowen ribbon frame cameras[1] and Askania Cinetheodolite[2] were originally designed for metric purposes. Table I compares their operating characteristics. The table does not include all cameras in common use at NOTS but merely gives single examples of each type. Likewise, only the most frequently used lens-and-shutter combinations are given.

These cameras differ widely not only in their operating characteristics but in the accuracy limits for data obtained from them. In determining the accuracy limitations of a camera and consequently its usefulness as a metric tool, the following factors are considered:

1. resolving power,
2. accuracy with which the lens and film orientation can be determined, and
3. accuracy with which the time of exposure of the missile can be determined.

Resolving power is considered here as the resolving power of the lens and film combined when photographing missiles under usual lighting. The resolving power is then defined as the reciprocal of twice the diameter of the finest line that can be resolved on the film under these conditions. Expressed mathematically

$$R = 1/2w \quad (1)$$

where R is resolving power in lines per millimeter and w is the width of the line in millimeters.

This definition is essentially in agreement with standard methods of determining resolving power with the exception that this is the resolving power under ordinary medium contrast, not with high contrast. Since high contrast in the negatives is rarely possible, the use of a resolving power based on that condition is invalid.

Resolving power is linked to accuracy in missile position in the following way. It has been experimentally determined that a line of medium contrast to the general background can be bisected to an accuracy of about 1/20 its width. Thus (using standard film-measuring devices) an operator can bisect a reference line and the missile line on the

film and record their coordinates. If both the reference line and the line on the missile are the finest lines resolvable, the standard error in the distance from the reference to the missile will be equal to $\sqrt{2}/20$ the width of each line (this allows for errors on both measurements).

Expressed mathematically

$$A_f = \sqrt{2}w/20 \quad (2)$$

where A_f is the standard reading error in millimeters on the film and w again is the width of the finest resolvable line in millimeters.

By substitution of Eq. 1 in Eq. 2

$$A_f = \sqrt{2}/40R \quad (3)$$

If the camera is to be used as a tracking camera, Eq. 3 is sufficient because if the resolving power is too low to give sufficient reading accuracy, a longer lens can be used so that reading errors result in correspondingly less error in missile position determination.

If the camera is not used to track the missile but has a fixed coverage, then reading accuracy must be considered in terms of the coverage desired with this camera. Essentially, the data desired are acceleration values, but since these are obtained by differencing two velocity values which in turn are obtained by differencing two position values, it is always necessary to obtain two more frames including the missile than the number of acceleration values desired from this one camera. Also the relation between reading accuracy on the film and acceleration accuracy must be defined.

If only position errors are considered it can be shown that

$$A_a = A_s\sqrt{6}/T^2 \quad (4)$$

where A_s is the standard position error of the missile in feet,
A_a is the standard acceleration error in feet per second squared,
A_s is the standard position error of the missile in feet, and
T is the time between successive frames in seconds.

But if the width of the frame in the direction of rocket travel is W_f in millimeters and the distance in feet in space that this film covers is W_s, projecting film readings into space:

$$W_f/W_s = A_f/A_s \quad (5)$$

Substituting Eq. 5 and Eq. 3 in Eq. 4:

$$A_a = \sqrt{3}\ W_s/20W_fRT^2 \quad (6)$$

W_s, the distance covered along the trajectory, is a function of the focal length of the camera and the distance from the camera to the missile, but since, n general, the focal length and camera distance can be varied, it is more useful to consider the distance in terms of the coverage desired. If the average velocity of the missile as it passes the camera is V and S is one less than the number of frames in which the missile is exposed, then:

$$W_s = VST \quad (7)$$

where T again is the time between successive frames.

If Eq. 7 is substituted in Eq. 6

$$A_a = \sqrt{3}\ VS/20\ W_fRT \quad (8)$$

Since there must be two more frames than the number of acceleration values and S is always one less than the number of frames in which the missile is exposed, S is always one greater than the number of acceleration values. If Eq. 8 is written in terms of both the acceleration error and the number of acceleration values desired and converted to G's,

$$A_a/S = \sqrt{3}\ V/640\ W_fRT \quad (9)$$

Since Frame Speed ($F.S.$) is the reciprocal of T, the time between frames

$$A_a/S = \sqrt{3}\ VF.S./640\ W_fR \quad (10)$$

If the acceleration error (A_a) is required to be less than one G and if only one acceleration value is required (which makes $S = 2$), for a velocity of 1000 fps and a resolving power of 10

Table II. Errors of Missile Exposure Time.

Camera type	Shutter type	Modifications to original camera	Random errors in time, μsec
Askania	Venetian blind	Camera dials illuminated by Edgerton Flash Lamps	3000
Mitchell	Rotating sector	Binary timing	300
Bowen	Rotating drum slit	Finer slits in drum; 1000-cycle timing pulses on film	3
General Radio	None (Edgerton Flash)		0.1
Fastax	Rotating prism	1000-cycle timing pulses on film	20

lines/mm, the highest frame speed over which acceleration data can be obtained with 35mm film would be 70 frame/sec.

In general, 5 to 10 acceleration values are desired from each camera. As a result, the Bowen cameras are used with the centerline of the 125-mm frame set approximately parallel to the portion of trajectory to be covered. On Bowen Film R = 10 lines/mm under most conditions. This value of R is low because of the movement of the missile image and the film during exposure.

So

$$A_a/S = V \times F.S./452{,}500 \qquad (11)$$

If A_a is 1 G, S = 10 and V = 1000, the highest usable frame speed is 45 per second. Data are usually obtained at the rate of 10 per sec or 30 per sec from Bowen cameras since missile velocities may be larger than 1000 fps.

But resolving power is not the only factor determining the accuracy of acceleration values. Under many conditions, it is necessary that the camera track the missile, so the accuracy with which the orientation of the lens and film can be determined is also important. With present camera mounts these orientations can be determined no better than ± 1 minute of arc and since high missile velocities require that the cameras be located some distance from the flight line in order that the operator can track the missile, these cameras have random errors in missile position of the order of 1 to 3 ft. This invalidates the use of high frame rates for ballistic purposes.

Even for cameras which do not track the round, it is necessary to determine the camera orientation to a fairly high accuracy because errors in this orientation introduce bias errors in the data. The ± 1 minute of arc accuracy obtainable is sufficient to make bias errors inconsequential.

Besides resolving power and camera orientation there are still errors in the time of exposure of the missile. Consider the following example: If a missile is traveling 1000 fps, to determine its position to ± 0.01 ft the time of missile exposure must be known to the nearest 10 μsec.

The errors in time of exposure of the missile as best determined for the cameras in common use are given in Table II.

In general these errors in time of missile exposure have a random error effect on the accuracy of velocity and acceleration data. When cameras are used to track missiles, timing errors are inconsequential if the tracking is smooth. The 3000-μsec error in Askania timing does not affect the accuracy of velocity and acceleration data if the operator is able to keep the missile in the center of the frame. But if he is not able to do so, the tracking error measured on

the film may not be the true tracking error at the time of exposure of the dials from which the azimuth and elevation angles of the camera are determined. If the angular error in tracking is greater than 3° per sec, timing errors appreciably affect the accuracy of the data.

A study of Table II indicates that in some cases the time of exposure can be determined very precisely. Often this cannot be done without studying the camera design and measuring some of its components. For a camera such as the Bowen it is necessary to obtain the dimensions of the shutter drum, shutter slit, and film drum and to measure the revolution rate of the shutter drum, the film speed, and the position of the missile in the film. This and other corrections to Bowen Cameras have been investigated previously.[3]

These, then, are the tools available for recording photographic data of missile flights. The Bowen and Askania cameras are used to obtain the greater part of metric data. The higher speed cameras are relegated to uses such as determining flame characteristics, for which they are better fitted. Data describing high frequency changes in missile behavior can be obtained only through use of metric electronic equipment. Since electronic equipment cannot be used under many conditions, it is essential that each camera be used in such a way that the utmost accuracy from that camera is obtained and the highest significant frame rates can be used.

Instrument Usage

The problem of using each camera at its maximum efficiency by making use of its good points and minimizing its weak points has been met at NOTS in the following ways:

1. Determine the sources of errors in each camera.
2. Modify cameras where possible to eliminate errors.
3. Determine the magnitude of those errors that cannot be eliminated conveniently by modification.
4. Use the camera in a location and manner which minimize the effects of remaining errors.
5. Have sufficient records to make it possible to overdetermine each trajectory point.
6. Apply statistics to obtain a satisfactory approximation of the trajectory point in question.
7. In terms of the solution obtained in item 6 above check the determination of errors from each camera (item 3) and also obtain an evaluation of the test data.
8. On a long term basis, design cameras which will have the characteristics required.

The development and use of Askania Cinetheodolite cameras exemplify the method of accounting for camera errors. The cameras were built and used by the Germans to obtain aeroplane flight data. For this use neither high frame speeds, high shutter speeds, high tracking rates nor good synchronization between the dials and the picture was needed.

In planning to use these cameras for missile flight data it was immediately obvious that the tracking rates would have to be increased. This was accomplished by eliminating the gear-drive making them free-sliding on their bearings. Since exposure of the dials indicating camera orientation was not well synchronized with the main shutter, better synchronization was achieved by illuminating the dials with Edgerton flashlamps whose discharge was timed to coincide as far as possible (±3 msec) with the opening of the main shutter. The high illumination and short exposure of the Edgerton flashlamps also effectively stopped the apparent motion on film of the azimuth and elevation dial readings.

With these modifications Askanias were installed as an integral part of the range instrumentation system. To minimize reading errors, the cameras were

placed as close to the flight line as the tracking rates and safety conditions would allow, and enough cameras were used to insure that at least three cameras would be photographing the missile at all times.

In reduction of data a method of least squares is used which permits the combination of data from any number of cameras simultaneously to obtain a solution. This method[2] permits weighing the data from each camera relative to its distance from the missile. The solution of missile position so obtained is, on the average, nearer to the true position than any other solution that can be computed. Since this solution minimizes the residual error from each camera, analysis of the errors from several flights permits a determination of the magnitude of the errors from each camera.

Checking the errors so determined over several tests indicated that some of them were not truly random. This led to an investigation of the azimuth dials and bearings and to the discovery that the dials were eccentric relative to the bearings. As a result, tests were designed to measure the eccentricity so its effect could be eliminated from the data during computation. At the present time, with all known corrections applied, missile position can be determined to an accuracy of ± 3 ft. This invalidates data obtained at high frame rates so the 4 per sec frame rate of the Askanias is adequate. For this reason they are used to cover those portions of the trajectory where changes in velocity and acceleration are slow, such as the afterburning flight of the missile. For documentary purposes, a Mitchell, Eastman High-Speed or Fastax camera may be used alongside the Askania at high frame rates to obtain documentary coverage simultaneously with the Askania data.

Experience in the use of Askania cameras has been incorporated in specifications for future tracking equipment with requirements as follows:

1. construction of a mount on which any one of several cameras can be mounted,
2. motor drive for the mount,
3. higher accuracy in the mount,
4. electrical circuitry permitting the starting of each camera automatically at a predetermined time in the missile flight,
5. longer and "faster" lenses, and
6. pulse operated or synchronously driven shutters.

The accuracies obtained with present Askania cameras using 24-in. lenses require only low reading accuracy. A reading error of 0.060mm results in an error of only 10 sec of arc in the determination of the direction of the line from the camera to the missile which, if the missile were 10,000 ft away, would result in a 1-ft position error. If future cameras are equipped with longer lenses, accuracies in missile position made possible with higher accuracies in the mount can be obtained with no greater demand on reading accuracies.

A study of the development of the Bowen ribbon-frame camera shows changes in its use and accuracy similar to that resulting from Askania use. Since this camera was designed originally for missile acceleration data, the changes have been more of degree than kind. Its present use and accuracy are limited principally by the resolution of the lens-film combination. Studies are underway to develop an $f/3.5$ lens with high resolving power for this camera. Since an $f/3.5$ lens would permit exposure times of the order of 10 μsec, blur on the film caused by image and film movement would be greatly lessened. It is expected that resolving powers of 20–30 lines/mm will be possible under these conditions.

Recently a 70mm camera has been developed[4] which can record at a rate of 450 pictures per sec. The film does

not move during the exposure so the resolving power of this camera may be high enough to validate data obtained at a 450 per sec rate.

In conclusion, the use of high-speed cameras for metric purposes illustrates a common experience — equipment well suited for one specific purpose may be entirely inadequate for a similar purpose. The extremely high frame speeds possible with the Fastax and Eastman High-Speed cameras are usually useless for metric ballistic purposes because of the accuracy limitations of the cameras and film. It has been necessary to design metric cameras with these accuracy limitations in mind and use them in ways that minimize their errors. Greater accuracies can be achieved only if emulsions and lenses can be developed which permit the use of shorter exposure times and which at the same time possess higher resolving power.

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Discussion

Dave Miller (Battelle Memorial Institute): I would like to get some confirmation of the apparent fact that your Askania data are correct within one to three feet, is that correct?

Mrs. Griffin: Yes. However, this depends on how far it is from the camera to the missile.

Mr. Miller: How far?

Mrs. Griffin: Within 10 or 15 thousand feet. The random errors in the azimuth and elevation angles measured with Askania cameras at the present time are of the order of one minute. There are also eccentricity errors in these cameras which can be corrected for but they seem to change with time, which makes it difficult to do so.

Mr. Miller: I wonder whether you could not release a number of flares with parachutes, so that several of them would always be within the field of view. They should move quite slowly, their motion should be substantially constant, and their motion could be computed, so that the positions of such flares as seen in the photographs could be used as a basis for determining the changes in azimuth and elevation, eliminating the need for dependence on the scales provided on the mounting of the camera.

Mrs. Griffin: We, at Inyokern, are right beside the Sierra Nevada Mountains. I don't know whether you have knowledge of the wavefronts there, but this region is where they do their experimental sail-plane flying. The wind velocities are of the order of 60 mph. They may change within 1000 ft and go in the reverse direction. I don't think it is practical.

Mr. Miller: Then possibly another site might be considered favorably.

High-Speed Cine-Electrocardiography

By JOSHUA J. FIELDS, LOUIS FIELDS, ELEANOR GERLACH and MYRON PRINZMETAL

This paper describes a method of using the high-speed camera in medical research on heart disease. Normal and abnormal human and animal hearts are photographed at high speed simultaneously with the electrocardiograph recording, to ascertain and to study the conditions revealed by similar electrocardiograms of human patients.

One of the most useful tools for studying the motion of the heart is the high-speed camera. For several years we have been taking slow motion pictures of the intact, beating heart of animals, before and after the experimental production of certain types of heart disorders. The magnification in time and detail has revealed much about the contraction not only of the whole heart but of the individual muscle fibres as well, in both normal and abnormal cardiac conditions. Careful analysis of these motion pictures has yielded a great deal of information concerning the mechanism and nature of heart action.

However, the clinical diagnosis of heart disease depends to a great extent upon what the electrocardiographic tracing reveals. In order to apply what we learned from the motion pictures to patients with heart disease, it was necessary to correlate the mechanical events of the heart with the electrical events. This meant, of course, recording the heart motion and the electrical trace simultaneously, and on the same film. In this way, corresponding mechanical and electrical events could be analyzed. After many trials and errors, a suitable technique was devised.

Procedure and Equipment

Figure 1 illustrates diagrammatically the relative positions of the equipment used. The camera is focused directly

Presented on October 10, 1952, at the Society's Convention at Washington, D.C., by Ethel Foladare for the authors. This work is from the Institute for Medical Research, Cedars of Lebanon Hospital, 4751 Fountain Ave., Los Angeles 29, Calif., and the Department of Medicine, University of California Medical School, Los Angeles, Calif. This study was aided by grants from the L. D. Beaumont Trust Fund, the Blanche May Memorial Fund, the Margaret Mayer Fund, L. Spitz, I. Berlin and E. Mannix.

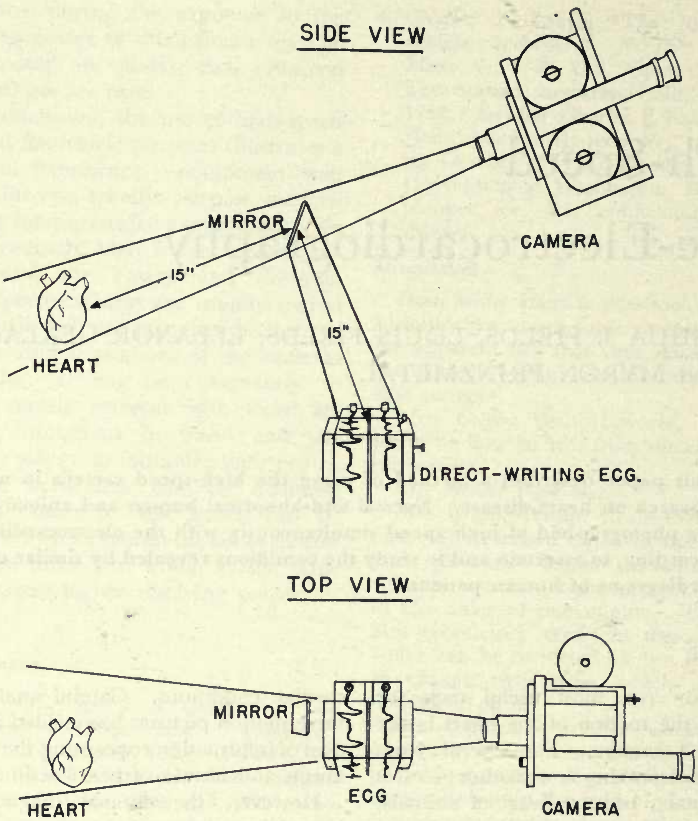

Fig. 1. Diagrammatic representation of the arrangement of equipment used for photographing the heart and electrocardiogram simultaneously. Note that the electrocardiogram is filmed by photographing its reflection in a mirror placed equidistant from the heart and the surface of the electrocardiographic apparatus.

on the heart at such a distance that the part of the heart to be studied fills approximately the left two-thirds of the field. The electrocardiographic machine is placed well below the level of the heart and is mounted on a jack so that adjustments in height are possible. The electrocardiographic machine and a first surface mirror are moved into position so that the reflected image of the trace occupies the right one-third of the field. The mirror image of the electrocardiogram will be in focus only if the distance from the surface of the electrocardiographic machine to the mirror is the same as the distance from the mirror to the heart. The mirror is mounted on a stand with a rack-and-pinion gear for adjusting its height; worm gears with a 100 to 1 ratio control its rotation and angulation. In this way, very fine adjustments in positioning the mirror are possible. Since we photograph the mirror image of the electrocardiogram, an arrangement of the circuits was made which inverts

the actual tracings and thus corrects the maged trace.

Cameras. Two types of cameras were used. A modified Bell & Howell "70" Specialist camera with a speed of 200 frame/sec was employed when visualization of gross movements of the heart was desired. The lenses used with this camera were a 75-mm Pan-Techar, *f*/2.3, and a 100-mm Pan-Techar, *f*/2.3. For extremely detailed analysis the Wollensak Fastax, 16mm camera was used with a 4-in. Wollensak lens, *f*/3.2. The Fastax was used for color pictures taken at 500, 1000 and 2000 frame/sec, and for black-and-white pictures at 5000 frame/sec.

Electrocardiographic Equipment. An ink-writing, dual-channel Brush Magnetic Oscillograph was found to be most suitable for recording the electrocardiogram. This machine has a paper speed of 125 mm/sec which is five times faster than the standard electrocardiographic paper speed. Each complex was thus magnified for great accuracy of analysis. In addition to the two writing pens, a time marker pen was installed at the edge of the paper. A pip every $\frac{1}{5}$ sec produced by a synchronous motor provided the time reference.

Light Sources. In all high-speed photography, the problem of a suitable light source exists. In high-speed medical photography, adequate light must be combined with a minimal amount of heat because one is dealing with living tissue. Excessive heat, of course, is injurious to tissue and precautions must be taken to keep all experiments under at least near-physiologic conditions.

For the Fastax pictures, a bank of from 7 to 20 General Electric 750-R lamps was used on the heart. Usually two or three of these focused on the electrocardiographic paper were sufficient. These lights generate intense heat and various attempts were made to overcome this — heat-absorbing glass, water cells, etc. However, in our setup, these were all awkward and difficult to manage. The simplest solution was to use 50-ft rolls of film in the Fastax camera and to turn on the lights after the camera was started and turn them off (by calculation) just before the film ran through. In this way, perhaps 15–20 ft of film were underexposed but the heart was subjected to the heat for only a very short time — from less than one second to a maximum of three and a half seconds. It was not uncomfortable to hold the hand in the light field for this period of time.

Pictures taken at 200 frame/sec require less light; General Electric RSP-2 lamps were used for this camera speed. A bank of five lamps directed at the heart from a distance of approximately 3 to 4 ft and one lamp on the electrocardiographic paper at about 2 ft were sufficient for good color. The heat problem was obviated by taking continuous film runs of not more than 25 ft at a time. Thus again, the lights were on for only a minimal length of time and the heat to which the heart was exposed was well within the physiologic limit.

For taking pictures of the beating human heart, the precautions and limitations which apply to photography of the experimental animals were even more strict. Thus we have been limited in the number and choice of the patients we have been able to study in this manner. However, a new type of lamp was loaned us recently through the kindness of John H. Waddell of the Wollensak Optical Co. This is the Fastlite, which is a compact unit with a built-in water cell. These lights have proved most satisfactory, for they are less cumbersome than the battery of hot lamps and they give an extremely intense light with a minimum of heat.

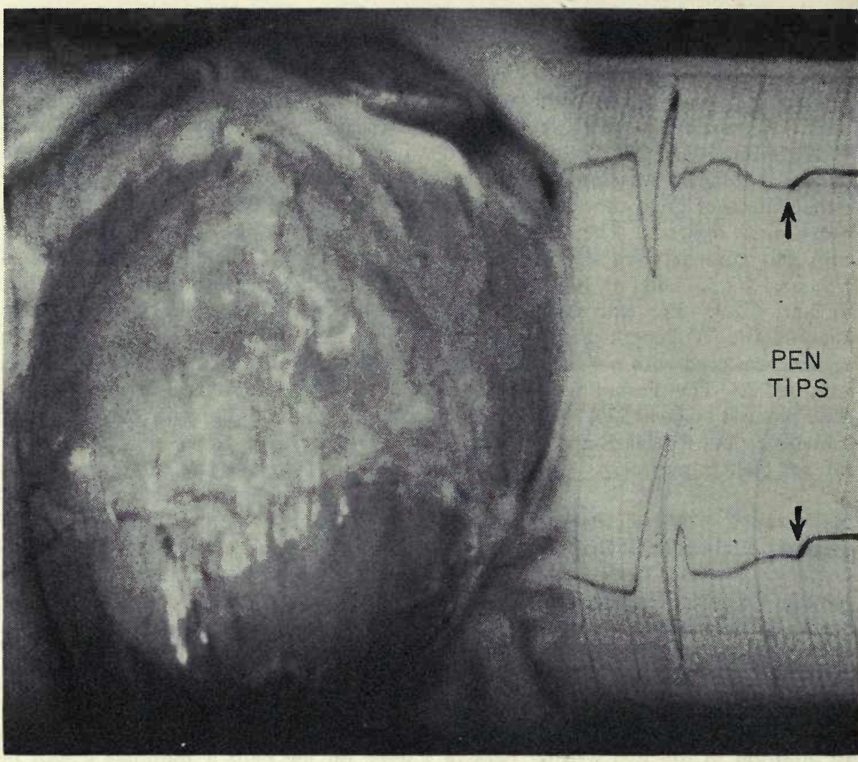

Fig. 2. Enlargement of 16mm frame photographed with the Fastax camera in black-and-white at 5000 frames/sec. The heart is at the left and the electrocardiographic trace is at the right. The ink-writing pens (indicated by arrows) have just finished writing the electrical counterpart of the contraction of the heart from two different leads.

Results and Comment

Figure 2 is an enlarged frame from one of the motion pictures taken by the technique of cine-electrocardiography. The heart is on the left and the mirror image of the electrocardiographic trace is at the right. The pen has just finished writing the electrical complex which corresponds to the contraction of the heart.

The apparatus used for positioning the mirror and the electrocardiographic machine makes it feasible to record photographically any or all parts of the electrical trace, i.e. one channel or two, a narrow strip or a wide one. It is also possible to vary the size and the field of the trace.

The most satisfactory *f* stop for both 200-frame and Fastax pictures up to 2000 frame/sec was found to be 4.5. This gives a fair depth of focus which is necessary since we are dealing with an object which has a field of motion of

about two inches in all directions. Also at this aperture the relatively small amount of light lost is well worth the definition obtained in the pictures. At a camera speed of 5000 frame/sec, the lens is stopped down to $f/8$ using the same amount of light as for the slower speed. In this way almost no loss in definition occurs.

If meticulous care is taken in positioning the heart, mirror and electrocardiographic machine, and careful attention is given to the lighting, exposure and focus, truly beautiful pictures result. More important than esthetic considerations, the films here described now make it possible to demonstrate definite relationships between electrocardiographic patterns and their mechanical counterparts. Although this technique has been in use only a few years, it has already yielded conclusive evidence confirming or disproving a number of previous theories concerning the mechanism of common cardiac disorders. The pictures can be studied repeatedly and thus have proved to be a valuable scientific instrument, for they reveal with fine detail and clarity, action that is not visible to the unaided eye.

Optical Aids for High-Speed Photography

By DAVID C. GILKESON and A. EUGENE TURULA

Several new series of highly corrected lenses for high-speed motion picture and professional 35mm use have been designed with focal lengths ranging from 3.7 mm to 2000 mm. Mirror optics have been used for the longer focal length lenses. Particular optical design and fabrication problems are discussed with reference to mirror optics. Special optical devices to aid the high-speed photographer are discussed.

In order to meet the many needs of professional users of 35mm motion picture cameras, Fastax cameras, 35mm still cameras and specialized applications of these cameras, several new series of lenses and aids have been developed. High-quality optical performance was a primary requirement because the lenses are to be used to record and study a variety of actions and instrument data over a wide field, for tracking, and for photographing and identifying distant objects in detail. The number of elements used in the construction of the lenses ranges from two to eleven (Tables I–V). The number necessary to achieve the performance desired is generally dependent upon the performance, aperture, and coverage requirements. The form and disposition of the elements within the system are dependent upon performance, aperture, coverage, space considerations, and special effects desired. With some exceptions, the number of elements used is no more than necessary and sufficient to meet the performance specifications of the user. The exceptions are the Raptar telephotos (Table II). It was much more important to have as short a back focus as possible for mechanical stability. If the back focus and general adaptability requirements were not important, achromatic doublets or triplets could have been used, depending upon the focal length.

The evaluation of lens performance by photographic resolution measurements has been well covered in previous papers.[4–10] Such a test, however, measures performance of the lens-film combination and the result depends greatly on the methods, techniques and

Presented on October 10, 1952, at the Society's Convention at Washington, D.C., by David C. Gilkeson and A. Eugene Turula, Wollensak Optical Co., 850 Hudson Ave., Rochester 24, N.Y.

Table I. Pro-Raptars

Focal length	f/No.	Diagonal coverage	Type and No. of elements
25 mm	$f/2.3$	61.2°	6 Gaussian type
35 mm	$f/2.3$	46.4°	6 " "
50 mm	$f/2.3$	33.0°	6 " "
75 mm	$f/2.3$	22.2°	6 " "
101 mm	$f/2.3$	16.8°	6 " "
152 mm	$f/2.7$	11.2°	4 Modified Petzval

Table II. Raptar Telephotos

Focal length	f/No.	Diagonal coverage	No. of elements
10 in.	$f/4.5$	6.8°*	4
12 in.	$f/4.5$	5.6°*	4
14 in.	$f/4.5$	4.8°*	4
15 in.	$f/4.5$	4.4°*	4
16 in.	$f/4.5$	4.2°*	4
18 in.	$f/5.6$	3.8°*	4
20 in.	$f/5.6$	3.4°*	4
24 in.	$f/5.6$	2.8°*	4

* Lenses marked with asterisk cover more than the angle specified for 35mm single frame with same high-quality performance.

Table III. Mirrotel (Catadioptric Telephotos)

Focal length	f/No.	Diagonal coverage	No. of elements
20 in.	$f/5.6$	3.4°	3
40 in.	$f/8$	1.7°	3
80 in.	$f/14$	0.85°	2

Table IV. Wide-Angle Lenses for 16mm Film

Focal length	f/No.	Diagonal coverage	No. of elements
3.7 mm	$f/1.5$	142°	8
5.4 mm	$f/1.5$	84°	8
12.7 mm	$f/1.5$	56°	11

Table V. Wide-Angle Lenses for 35mm Film

Focal length	f/No.	Diagonal coverage	No. of elements
8.3 mm	$f/1.5$	142°	8
11.2 mm	$f/2.0$	84°	8

targets used. Strict control of the variables affecting the measurement is very necessary. Other ways to evaluate lens performance have been discussed also.[11–13] Since the subject is well covered by these authors, no attempt will be made to discuss any of the methods as applied to the lenses which are the subject of this paper other than to state that the "Rayleigh-Conrady" tolerances[14] were used as the basis for the comparison of these lens designs with other similar designs, as well as extensive photographic and optical bench comparisons.

Spherical Mirror Optics (Mirrotels)

Since catadioptric photographic objectives are recent developments in the field it is felt that some discussion of the spherical mirror is necessary.

The advantages of the spherical mirror as an image-forming device have been known for many years. The spherical aberration of a single concave mirror is eight times smaller than that of a single lens of equal aperture and focal length even when the lens has the most favorable bending for minimum spherical aberration.[2] Where high resolution is desired, spherical aberration is objectionable. Therefore, spherical mirrors have been made aspheric by hand correction to minimize the spherical aberration to acceptable limits. To have the advantage of large-aperture spherical mirrors with minimum spherical aberration, Schmidt[1] in 1930

added a corrector plate. Parabolic mirrors with corrector plates have been used. Only recently (Bouwers & Maksutov[2,3]), however, has the spherical aberration of the spherical mirror been corrected by the addition of commercially reproducible all-spherical correctors, thus making available the very real advantages of reflective optics on a wider scale than ever before. Perhaps the most important and most obvious advantage of the spherical mirror is the complete absence of chromatic aberration. If a diaphragm is placed at the center of curvature of a spherical mirror no coma, astigmatism or distortion can occur, for the straight line containing the center of curvature parallel to any given ray of light may be regarded as an axis of the system. There is curvature of field convex to the incident rays, the radius of field curvature being about equal to the focal length for objects at infinity. Field curvature is rarely a problem when the field of view is restricted. Where field coverage relative to focal length is large, suitable field flatteners or curved film may be used.

An inconvenience of the spherical mirror is the reversal in direction of the light rays. There is some loss of light since the object or image receiver intercepts part of the useful beam. The "shadow effect" can be serious with an extensive field of view and small relative aperture. The reversal in path, however, is a real and distinct advantage for long focal length objectives because the "folding" reduces total length to about one-third that of a refractive optical system of equal focal length, thereby giving a more compact and lighter system. Reflective optical systems require different mounting techniques and are much more sensitive to misalignment and spacing changes than refractive optical systems. The correction of spherical aberration is achieved by the addition of a weak spherical corrector lens closely concentric with the primary spherical mirror. With spherical aberration corrected, with coma, astigmatism and distortion eliminated by choice of stop position, and with no chromatic aberrations present, the resolution is primarily limited by diffraction. The spherical mirrors are mounted in a manner to eliminate focus shift caused by temperature variations. Such mounting is imperative by reason of the very sensitive air space between mirror surfaces.

Wide-Angle Lenses

The 84° and 142° wide-angle lenses for 16mm film and 35mm film listed in Tables IV and V have proven to be invaluable where an extreme field of view is required. The systems of the lenses are basically reversed telephotos in form. An extreme depth of field is possible for the lenses even at the maximum $f/1.5$ and $f/2.0$ apertures because of the very short focal lengths and small residual aberrations with the exception of distortion. The resultant distortion is characteristic of extreme wide-angle lenses of high relative aperture. Successful application of the 142° lenses in moderately high-speed motion picture photography is discussed by Bauer and Blake of the Douglas Aircraft Co.[15] The lenses are used to record automatically instantaneous instrument data shown on a wide variety of instruments over a large area where the distance from panel to camera is restricted. In many cases the instrument or objects must be located in azimuth and elevation within the distorted field, necessitating correction charts to compensate for the distortion present in the optical system. The charts are made by photographing an accurately drawn rectangular grid pattern at a predetermined reduction with the lens whose field is to be plotted. The grid spacings are drawn, in both azimuth and elevation, to subtend a given angle in the field of the lens. The photograph obtained is then enlarged with a distortion-corrected lens to a specified

size. The result is finally reproduced in the form of graph paper for locating and recording the data or objects.

The new 12.7 mm $f/1.5$ Cine Raptar for 16mm cameras has been designed to fill the need for a distortion-corrected lens with minimum residual aberrations where extreme coverage is not a primary requirement. It has a diagonal coverage of 56°.

In addition to the basic lenses and lens mountings required, special attention has been given to the varied needs of the users. The most frequent requirements are for compensation of focus shift with temperature changes, and for reticle reference-marking attachment. Normal focus shift with temperature changes may be accomplished by a calibrated air-space change between favorably disposed elements of the system, or by spring-loading the elements of the system against suitably placed invar rods. The method used is determined by the lens design. The correction of focus shift with temperature is most necessary for long focal length lenses.

Many applications of high-speed motion picture photography in the field require a reference mark within the picture area. This is accomplished with an optical reference-marking attachment whose residual aberration contributions to the primary lens must be kept at a minimum. The optical reference-marking attachment is composed of a cross-line engraved field lens and a high-aperture lens which images the cross lines and the image due to the primary objective on the film at 1:1 ratio.

This attachment is par-focussed and can be used with any of the high-speed motion picture camera lenses, and can be adapted easily to other applications.

A means for focussing the lenses is often required and provision is made for focussing the majority of the lenses wherever it is required. There is also some demand for viewing devices through which it is possible to follow the action being photographed. Where required, such devices can be manufactured and supplied. Every attempt has been made to supply to the user in the field a wide variety of lenses, devices and aids to simplify and expedite his work, which is so essential in the common defense effort today.

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A High-Speed Rotating-Mirror Frame Camera

By BERLYN BRIXNER

A high-speed framing camera of some general utility has been developed at the Los Alamos Scientific laboratory and operated up to 3,500,000 frames/sec. Use is made of a rotating mirror and 170 framing lenses working at f/26 to produce frame pictures 1.2 × 1.4 cm in size. Another model operating at 100,000 frames/sec has been made with 90 circular frames 2 cm in size.

THE CONTINUOUS-WRITING high-speed frame camera herein described was made for the detailed study of explosive phenomena and is primarily useful for the photography of high-speed events that are self-luminous or illuminated by very intense explosive light sources using an argon atmosphere.[1] Frame cameras operating up to 500,000 frames/sec have been made,[2,3] but the systems used probably cannot be increased in speed to any great extent because of the limitations of the strength of the rotating mirrors used. The camera to be described was designed for operation up to 3,400,000 frames/sec and makes use of a small mirror so that much higher rotational speeds can be obtained.

Optical System

The principle of operation of the camera is the same as has been used in highest-speed cameras previously made in that an object to be photographed is imaged on the surface of a rotating mirror and then relayed to successive positions on the film by a series of relay lenses. The novel feature of this camera is the use of a small, thin, two-faced rotating mirror and the division of the optical system into two sections so that appreciable blind time is avoided.

Figure 1 shows a schematic isometric view of the optical system. The objective lens L_1 forms an image I_1 in the field lens L_2. The beam-splitting mirror M_1 divides the light from I_1 into two paths A and B. Consider path A first. The combined relay and field lens L_{3A} relays the first image I_1 to the position I_{2A} near the surface of the rotating mirror RM, using the mirrors M_{2A} and M_{3A} to properly direct the light path. The mirror M_{3A} is so placed that the rays forming the image I_{2A} are reflected from the surface of the rotating mirror RM into the final relay lens L_{4A} to form the image I_{3A} in the film plane F_A. A series of lenses identical to L_{4A} are placed in the 180° arc shown to form

Presented on October 9, 1952, at the Society's Convention at Washington, D.C., by W. E. Buck for the author, Berlyn Brixner, University of California Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, N.M.

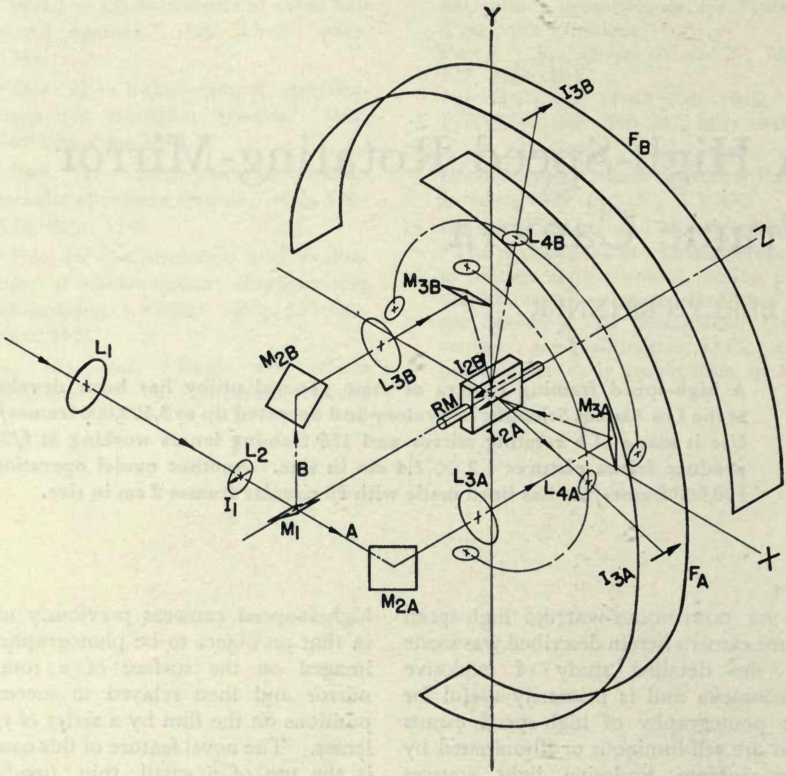

Fig. 1. Optical diagram of high-speed frame camera.

a series of pictures on the film F_A. This lens and film arc records pictures for the rotating mirror in the range of ±45° from the position shown. For positions of the rotating mirror beyond that range it is necessary to follow the optical path B which is seen to be at 90° around the Z axis from path A. The combined field and relay lens L_{3B} then relays the image I_1 to the position I_{2B}. The image-forming rays are so directed that they pass into the relay lens L_{4B} to form the image I_{3B} in the film plane F_B. It is thus seen that pictures are obtained for another 90° range of the rotating mirror, adjacent to the previous 90° range, or a total of 180°. Since both faces of the rotating mirror are polished, pictures can be obtained for the entire 360°, with the exception of the region obscured by the mirrors M_{3A} and M_{3B} which amounts to less than 3% of the cycle in a practical case. There are always two images on the rotating-mirror face but the displacement of the relay lens arcs away from the X-Y plane insures that light from only one reaches a relay lens at any one time. Achromatic doublet lenses are used throughout since these give excellent resolution over the small angular field required. The axes of the final relay lenses are coincident with the central optical path and hence the film plane is a conic rather than a cylindric section as shown. The various lenses of the system are assigned focal lengths such that the pupils are located

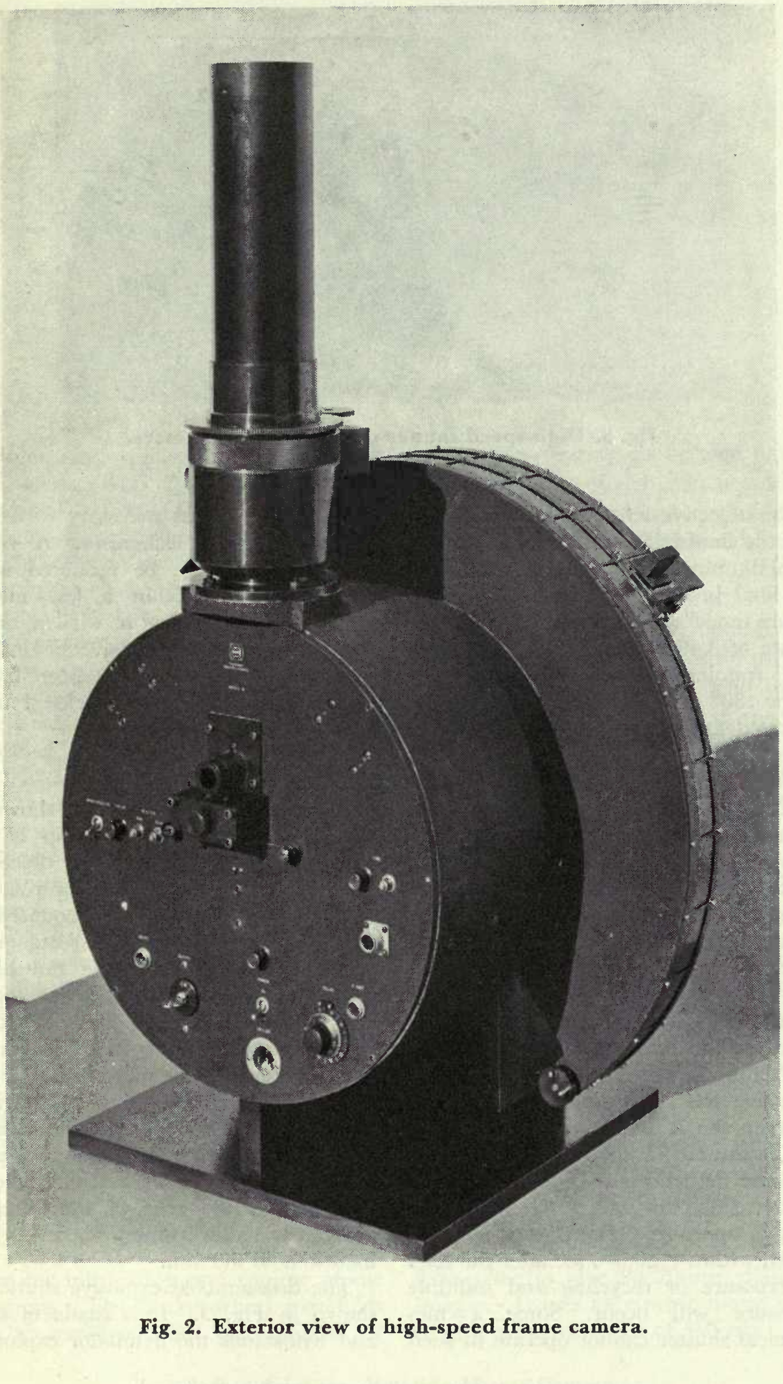

Fig. 2. Exterior view of high-speed frame camera.

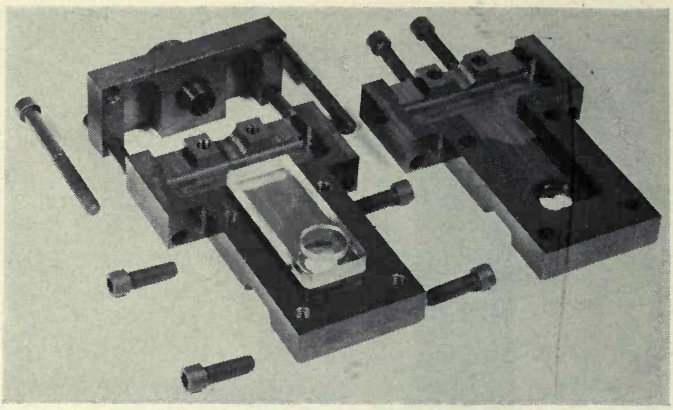

Fig. 3. High-speed shutter used with frame camera.

at the objective lens, the beam splitter, and the final relay lenses. This insures even illumination for all the points of the final image and the minimum exposure time for each picture. To obtain a rate of 3,400,000 frames/sec, a series of 85 framing lenses were used for each of the 180° arcs and the rotating mirror operated at 10,000 rps (revolutions per second).

The loss of light entailed by the use of a beam-splitting mirror may be objectionable to some users even though a factor of 2 or 3 in exposure usually makes only a minor change in the final print quality. In that case the use of a roof mirror in place of the partial reflecting mirror is advisable. The use of a roof mirror also introduces the need for the objective lens to be of twice the aperture and may result in appreciable distortion in the final image. The objective lens axis is then placed midway between the A and B optical paths.

The shutter for the camera is located between the field lens L_2 and the beam splitter, since this part of the system has a small aperture. The shutter must be closed within 1/20,000 sec after the start of exposure or recycling and multiple exposure will occur. Since a mechanical shutter cannot operate in such a short time it was necessary to devise a much faster mechanism. A small block of glass can be rendered sufficiently opaque within a few microseconds by shattering it with a shock wave from a high-explosive detonator. Such an arrangement has been found practical if the glass is enclosed in a suitable steel case.

Camera Construction

The exterior of the camera is shown in Fig. 2. The tube at the top is the focusing mount for the 24-in. objective lens used. The electrical controls for operation of the camera are mounted on the circular end plate. The rectangular projection on the plate is the high-speed explosive shutter mentioned above. It is easily removed for loading with a glass block and the explosive detonator. The viewfinder is located just above the shutter. The adjustable time-delay and detonator firing circuits are housed within the camera body. The two semicircular relay lens rings and film holders are seen at the rear of the camera. Standard 35mm camera cassettes are used to hold the film.

The disassembled explosive shutter is shown in Fig. 3. It is made of steel and withstands the detonator explosion

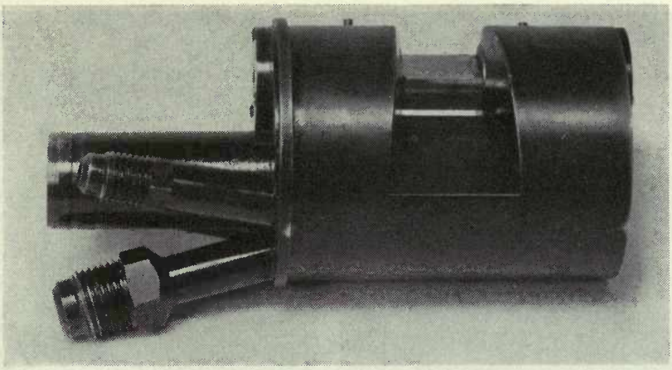

Fig. 4. 10,000-rps turbine with rotating mirror.

without any noticeable deformation of the piece. The $\frac{1}{2}$-in. round optical aperture is near the center of the shutter. Circular pieces of transparent plastic are fitted in these holes to prevent glass fragments from entering the camera. The block of $\frac{1}{2}$-in. plate glass fits in the long groove. The electric detonator (not shown) is pressed against the end of the glass block by means of the hollow screw which fits in the shutter cap. A chamber is formed around the detonator so that the explosive gas pressure will not be too high before exhausting to the outside through the ports in the cap. The detonator is loaded after the shutter has been assembled and fitted to the camera.

The 10,000-rps rotating mirror and air turbine drive[4] is shown in Fig. 4. The mirror has faces $15\frac{1}{2} \times 17\frac{1}{2}$ mm and is 8 mm thick. The air and oil lines for driving and lubricating the unit are at the left. The compact construction was achieved by combining the mirror and turbine into a unit. There is a turbine and sleeve bearing at each end of the mirror. Dural bucket wheels are press-fitted on the mirror shaft. Ordinary No. 10 grade lubricating oil at 100 psi in a circulating system is used for lubricating and cooling of the bearings. The bucket-wheel manifolds are so arranged that the exhaust air sweeps the bearing-oil leakage out the exhaust pipe so that it will not deposit on the mirror and optics inside the camera. A $19 \times 17\frac{1}{2}$ mm drive has also been constructed so that image cutoff is avoided when the mirror is at 45° to the optic axis. This larger size mirror operates with very little strength safety factor at 10,000 rps, and its use is avoided when the highest speed of operation is required.

The camera has an effective aperture of $f/26$ and the final image size is 12×14 mm. Dynamic resolution tests with Shell Burst Panchromatic film give 30 lines/mm over the entire picture area. Diamond shaped stops[5] are used for the lenses as it has been found that there is no practical loss of resolution relative to a circular or rectangular stop of the same linear dimensions. The diamond stop has the advantage that the effective time of exposure is about two-thirds of that obtained by a rectangular stop.

The design of the camera is such that it is adaptable for a wide range of operating speeds. Another model almost identical in appearance to the one illustrated was made for operation at 100,000 frames/sec to give 90 20-mm diameter images. It uses an electric motor drive to give a mirror speed of 550 rps.

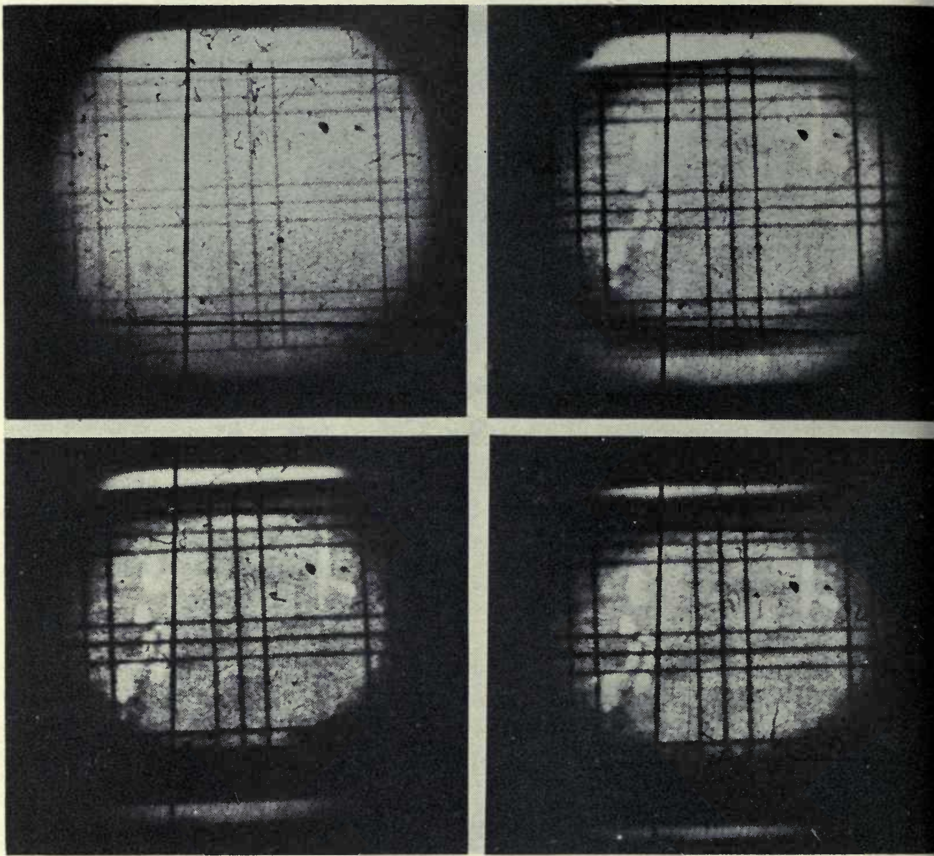

Fig. 5. Photograph of the surface of an explosive-driven metal plate.

Sample Photographs

The photographs in Fig. 5 are a few of the frames from a series showing the surface of an explosive-driven metal plate[6] by reflected light. An explosive flash with an argon atmosphere was used to illuminate the plate and the camera was operating at about 3,500,000 frames/sec. The first frame shows the surface of the plate just before it was struck by a shock from behind. The dark lines are from the reticle in the optical system of the camera. The fine triple-line reticle is painted on the plate. The second frame shows the plate within 0.3 μsec after being struck by the shock. There is a considerable increase in the contrast of the reticle lines and trivial imperfections of the plate surface show up strongly. A velocity of 3,000 m/sec is attained almost immediately and the movement is easily detected on the succeeding frames by examination of the relative positions of the two reticles.

Figure 6 shows a contact print of the sequence of negatives obtained when exploding primacord was photographed in silhouette at 1,700,000 frames/sec. A scale has been placed adjacent to the

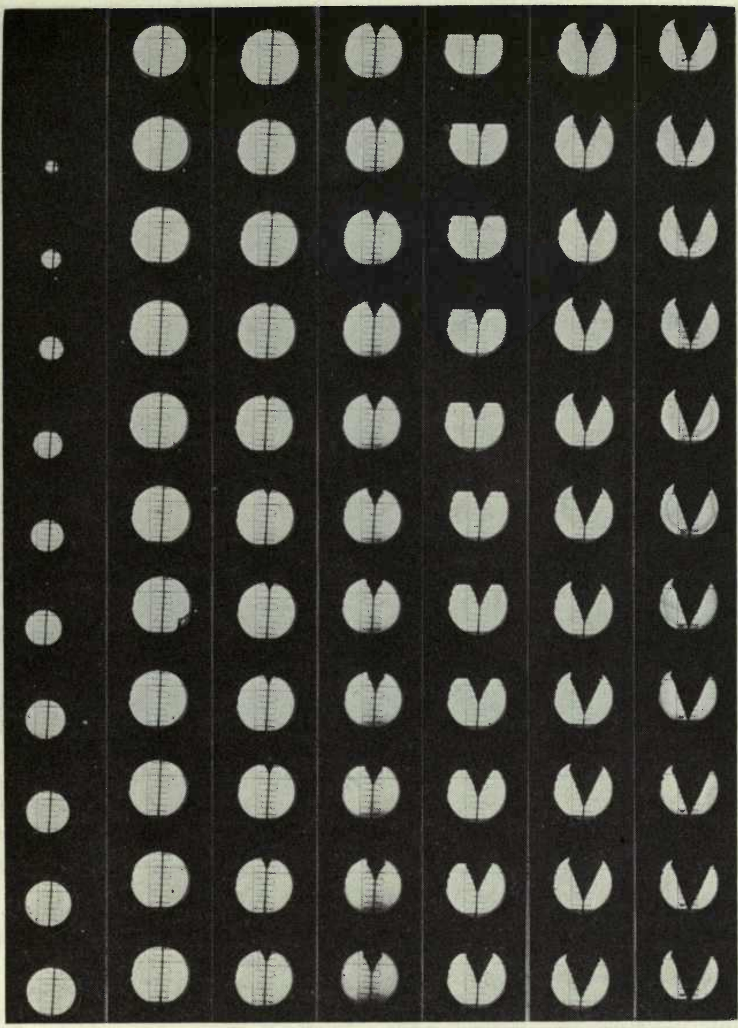

Fig. 6. Contact prints of film showing exploding primacord.

primacord to facilitate measurement, and an explosive light source was used. The early frames show the light source as it brightens up, and shortly thereafter the shock wave from the primacord can be seen to progress across the illuminated area. The shock wave was found to be traveling at 6.2 mm/μsec along the primacord.

Figure 7 shows a 10× enlargement of one of the frames from Fig. 6.

Conclusion

The continuous-writing frame camera described is the fastest practical camera so far produced. Its use is probably largely limited to the study of high-explosive phenomena where the destruc-

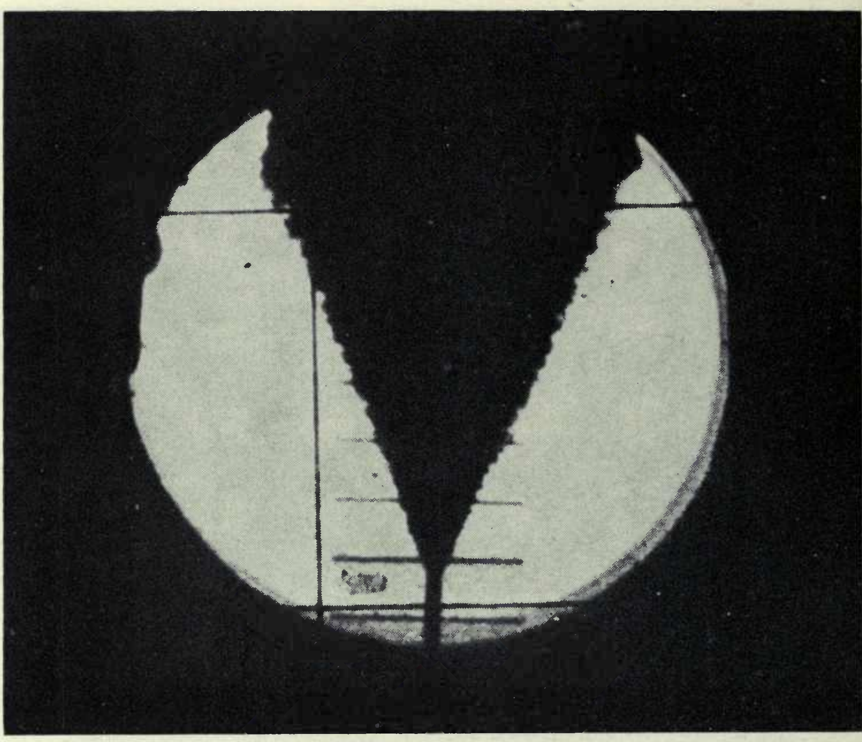

Fig. 7. 10X enlargement of photograph showing exploding primacord.

tion of the object being examined is of no importance. Somewhat slower models of the camera (with even better space resolution) can undoubtedly be used to obtain reflected light photographs of objects illuminated by the high-intensity gas-discharge lamps. The camera is rugged in construction and can be readily moved about. It has been found that the sequence of 50 to 100 frames obtained is quite adequate for the studies so far encountered.

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Discussion

Dave Miller (*Chairman of the Session; Battelle Memorial Inst.*): I would like to congratulate the author, Berlyn Brixner, on making some progress toward a name for this camera, which it needs rather badly. It has often been called the "Rotating-Mirror Camera." There is a good deal of ambiguity there because the term "Rotating-Mirror Camera" might apply to a camera which simply causes an image to move continuously on a film and might not necessarily refer to this type of camera in which a reflected beam of light rotates about a focused image as a center. I have invented my own name for this type of camera which I shall describe at the next session of this symposium.

Jean St. Thomas (*Civil Aeronautics Admin.*): How do you eliminate schlieren patterns of the air surrounding the mirror, or does the mirror run in a vacuum?

[*Mr. Buck, who read the paper, replied. The following more tightly knit answer has been supplied by the author.*] Schlieren patterns in air are made visible by means of collimated light beams or an equivalent system using a point light source and a restricting field stop in a suitable optical system. The image on the camera's rotating mirror is formed by *f*/32 beams and these are sufficiently large so that no schlieren patterns are visible. The optical disturbances in the air surrounding the mirror could easily deteriorate the final image resolution were it not for the fact that they occur adjacent to the image on the mirror and hence have only a short optical lever arm with which to operate. If there were trouble of this kind, it could be greatly reduced by using some gas with a high sound velocity for the mirror atmosphere, for example helium or hydrogen. The latter is dangerous to use because of its highly inflammable and explosive nature.

Mr. Miller: I can't recommend rotation in a vacuum as a solution to the problem of these high-speed rotating mirrors. That caused us no end of grief at NACA; because of the absence of air, oil spattered without limit and the very negligible amount of oil that came through the bearing came up onto the rotor and spattered off onto the optics. It presented a problem without any solution. We tried for months every conceivable sort of trap to eliminate this spattered oil, but we were not successful. And because of that fact we had to resort to an electromagnetic suspension and an electromagnetic drive for the rotor, as long as we spun it in the vacuum. With the electromagnetic drive I understand this rotor, weighing two-thirds of a pound, eventually reached a speed of 4,000 rps, corresponding to 800,000 frames a second for that camera.

Acoustic Problems at the "Waldbühne" Open-Air Sound Theater in Berlin

By HANS SIMON

Acoustic problems arising in connection with the reproduction of sound films in an open-air theater are discussed. The proper arrangement of loudspeakers as well as the careful adjustment of their beam direction is of utmost importance. It is demonstrated that a uniform sound level with a considerable increase in volume can thereby be attained. Furthermore, as a result of the concentration of sound waves, a substantial increase in the frequency band will occur. The amplifier power necessary for the required acoustic output is calculated.

THE OPEN-AIR theater known as Waldbühne Berlin, built about twenty-five years ago, has now been arranged for the reproduction of sound films. Figure 1 shows the screen with the loudspeaker installations mounted on both sides. The front row of seats is about 164 ft and the back row 394 ft from the screen. For these viewing distances a 36 × 26 ft screen was used. Reproduction of sound films had to be satisfactory for the entire audience of 25,000 persons. To meet this requirement it was essential to achieve adequate synchronization of picture and sound and uniform sound level in all parts of the arena.

Synchronization

It is obvious that acoustic quality in an open-air theater is dependent on very different conditions from those in a closed room. In an open-air theater all the effects due to reverberation are absent and only the laws for linear and unrestricted diffusion of sound waves need be considered. Their velocity of diffusion, however, will be of particular importance. The long distances sound must travel in an open-air theater tend to produce an undesirable effect on the audience due to the time-lag between picture and sound. Consequently, scenes of rhythmic movement such as a dance would deviate from the rhythm of the accompanying music. Similarly, it would be especially disturbing if the sound produced by a singer were not synchronized with lip movements. It is therefore of the first importance that the phase difference between picture and sound be reduced to a minimum. The solution which proved successful for the Waldbühne Berlin is described as follows.

As far as is now known, the following

A contribution submitted on September 23, 1952, by Hans Simon, 6 Xantener Str., Berlin W. 15, Germany.

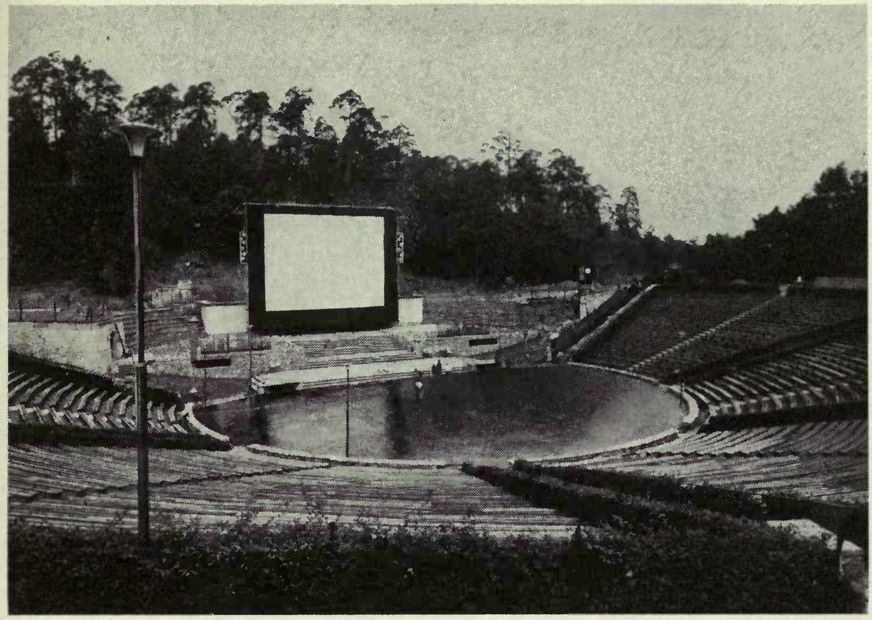

Fig. 1. The Waldbühne Berlin Open-Air Sound Theater

method is the only one that can be used satisfactorily to reproduce sound films for large audiences. The method used takes advantage of the ability of human eyes and ears to perceive optical and acoustic phenomena belonging together as synchronous when the time-lag between them is not too great. According to experience the time-lag must not exceed 0.1 sec*; whether the picture or the sound precedes is unimportant. Therefore, if at A (Fig. 2) there is perfect synchronization, then virtual synchronization will occur for all viewers seated within a range of 112 ft (i.e. 0.1 sec) each side of A. Hence the radius of virtual synchronization is 224 ft. Since the value of 0.1 sec may not be exceeded for the reasons stated above, the synchronization area of 224 ft must be taken as the limit beyond which no satisfactory reproduction of sound films is possible. *Therefore, the use of an open-air theater for sound will always be limited to a linear distance of 112 ft either side of the calculated line of synchronization.* Satisfactory vision in this area is dependent solely on the size and illumination of the screen and, therefore, on the light output of the projector.

The vertical section of Waldbühne Berlin (Fig. 2) shows that the distance of A from the screen corresponds to 0.25 sec (sound path = 276 ft). To obtain synchronization at A the sound produced by the loudspeaker must precede the picture by 0.25 sec. This may be accomplished by using a special copy of the film or by altering the length of the film loop between the film gate and the sound head of the projector. Since this is a problem of construction it will not be discussed further.

In actual practice, this method of preceding picture by sound produced

* The normal limit used in synchronization practice.

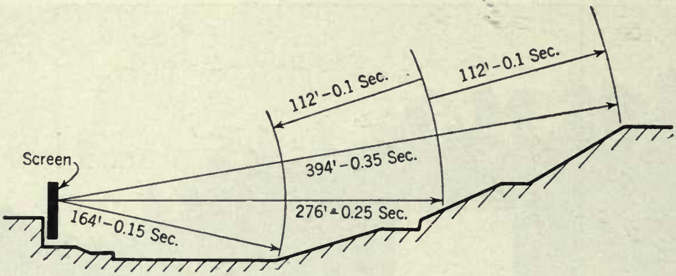

Figure 2.

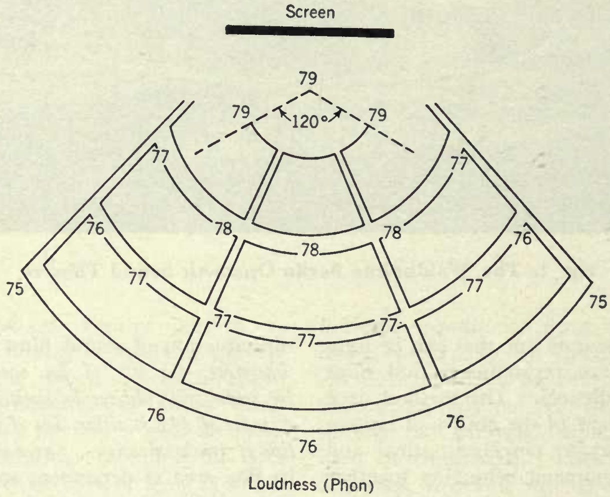

Figure 3.

acceptable synchronization throughout the 224-ft area.

Uniform Sound Level

Uniform sound level for all parts of the arena was obtained by appropriate distribution of the loudspeaker units and by carefully adjusting their beam direction. Each of the loudspeaker units consisted of two groups of three speakers of different frequency characteristics. Numerous tests showed that the most suitable arrangement was obtained with the loudspeaker units placed on both sides of the screen (Fig. 1) at about two-thirds of its height.* A great many tests and measurements were necessary to obtain the correct adjustment of the sound direction for all the loudspeaker units. The final result of the measurement of the sound levels may be seen in Fig. 3. With an average

* This distance was determined by the structure of the Waldb¨hne Berlin and must not be assumed to be generally acceptable.

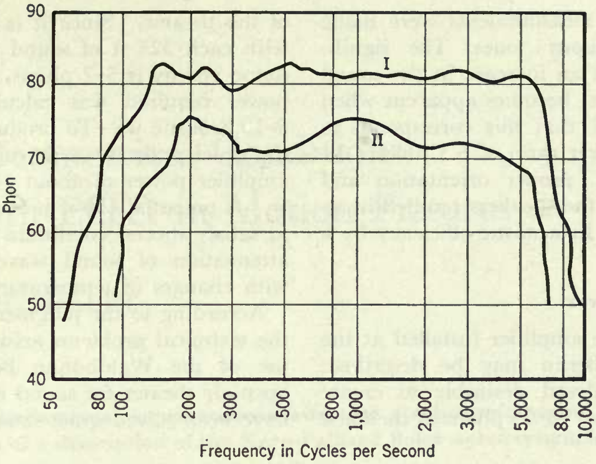

Figure 4.

sound level of 77 phons† the deviations were nowhere more than 3 phons. The final arrangement of the loudspeaker units and their adjustment resulted in a considerable improvement of the sound level through the frequency range. This result, based on theoretical calculation, is produced by the effect of concentration due to the adjustment of the loudspeaker units.

A comparison of the loudspeaker arrangement described above with that of an arrangement located at one-quarter of the screen height without special adjustment of the loudspeaker direction may be of interest. Figure 4 shows the frequency characteristics taken at a distance of 262 ft from the loudspeaker units. Curve II refers to the loudspeaker arrangement at one-quarter the screen height while Curve I refers to the final arrangement. The data for both curves were obtained with the loudspeakers equally powered (50 v), corresponding to an amplification power of about 40 w. Comparison of the two curves shows an increase in the sound level of about 8 phons within the range of 100–8000 cycles/sec. Concentration of the sound waves produced considerable improvement in acoustic efficiency and eliminated overloading at high sound levels, i.e. distortion.

In addition, it is evident from the two curves that a notable enlargement of the frequency band in both high and low ranges has occurred. If J_I and J_{II} be the amount of energy of sound at loudspeaker units I and II, the following equations apply:

$$10 \log \frac{J_I}{J_0} = a$$

$$10 \log \frac{J_{II}}{J_0} = a + 8$$

where J_0 is the sound energy at threshold. Subtracting the first equation from the second:

$$10 \log \frac{J_{II}}{J_0} - 10 \log \frac{J_I}{J_0} = 8$$

$$\text{or} \qquad 10 \log \frac{J_{II}}{J_I} = 8$$

$$\log \frac{J_{II}}{J_I} = .8$$

$$\frac{J_{II}}{J_I} = 6.3$$

† The loudness level, in phons, of a sound is numerically equal to the sound pressure level in decibels, relative to 0.0002 microbar, of a simple tone of frequency 1000 cycles/sec which is judged by the listeners to be equivalent in loudness.

These sound measurements were made using continuous tones. The significance of such an increase in the sound level (8 phons) becomes apparent when it is realized that this corresponds to an actual power ratio of 6.3 times. In other words, proper orientation and placement of the speakers resulted in an improvement in acoustic efficiency by a factor of 6.3.

Amplifier Power

Finally, the amplifier installed at the Waldbühne Berlin may be described. It was considered desirable to create a sound level of 70–75 phons at the back of the theater. Since it is known that with each 325 ft of sound path loss of sound energy is 5–7 phons, the acoustic power required was calculated to be 8–10 acoustic w. To produce this with the loudspeakers used called for an amplifier power of about 120 electrical w. A potential 150-w unit was installed to satisfy special conditions such as the attenuation of sound waves occurring with changes of temperature.

According to the judgment of experts the technical problems arising from the use of the Waldbühne Berlin as an open-air theater for sound reproduction have been solved quite satisfactorily.

Errata

Raymond Spottiswoode, N. L. Spottiswoode and Charles Smith, "Basic principles of the three-dimensional film," *Jour. SMPTE, 59:* 249–286, Oct. 1952.

Page 254, column 2, footnote, last line:
For: 1 metric $\rho = 10{,}000/\text{distance in cm}$.
read: Distance in metric $\rho = 10{,}000/\text{distance in cm}$.

Page 256: Fig. 2b title, next to last line:
For: When $t_c > t_c$, $l - r' > l - r$
read: When $t_c' > t_c$, $l - r' > l - r$

Page 271, column 2: The equation numbered 11 should be numbered 18.

Some Geometrical Conditions for Depth Effect in Motion Pictures

By EUGENE MILLET

The fundamental considerations affecting stereoscopic vision are used as a basis of a description of the Kern-Paillard Bolex stereo system for 16mm film.

THE PERCEPTION of a stereoscopic image is a complex phenomenon; the process of synthesis whereby one forms an accurate idea of an object observed in all its dimensions from the elementary data of the senses involves both psychology and cerebral physiology.

It is obvious that, for purposes of artificially producing the impression of depth by means of plane images, only the sensory aspect of the problem need be considered; the illusion would be complete if all the sensations present upon observation of the object in nature could be produced artificially at the same intensity as in natural vision.

The purely optical sensations due to the two retinal images depend on conditions of definition, accommodation, coloration, distribution of light and shade, perspective, and movement of the object. In addition, the state of convergence of the eyes produces certain muscular sensations which play an important part in effortless depth vision.

A contribution submitted October 14, 1952, by Eugene Millet, Development Dept., Paillard S.A., Yverdon, Switzerland; and Paillard Products, Inc., 265 Madison Ave., New York 16, N.Y.

When an object located at a finite distance in nature is observed with the naked eye, the axes of the two eyes converge upon a certain point on the object, and its various elements are seen at unlike angles by the left eye and the right. In a stereoscopic cinematographic projection, the spectator views two images on a screen, whose dimensions are generally different from those of the object originally photographed; moreover, the angle at which each eye sees the object depends on certain of the technical conditions under which the shot was taken. We shall inquire, by a simple geometrical approach, what conditions must be satisfied in order that the spectator will see the projected image at the same angles at which he might have seen the object in nature.

Conditions for Natural Relief

We define "natural relief" in the following way:

Let there be an object A occupying a certain space in nature. Having photographed this object, we view a pair of images A' on a projection screen. We speak of *natural relief* if all the dimensions of A' are seen by each of the spectator's eyes at angles equal to those at which

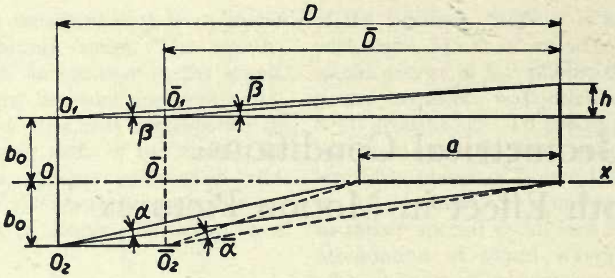

Fig. 1. Relationship between transverse and axial enlargement.

each eye respectively would see all the dimensions of A in nature when stationed at the desired distance from A.

First let us recall the relationship subsisting between transverse enlargement and axial enlargement in direct vision of an object in nature (Fig. 1).

Let Ox be the ocular axis, and let h be a transverse object element and a an object element along Ox. The elements h and a are assumed small relative to the distance D. Designating the ocular base by $2b_o$, we have

$$\beta = h/D; \tag{1}$$

$$\alpha = ab_o/D(D - a). \tag{2}$$

If the observer stations himself at a point $\bar{O}$, we have

$$\bar{\beta} = h/\bar{D}; \tag{$\bar{1}$}$$

$$\bar{\alpha} = ab_o/\bar{D}(\bar{D} - a). \tag{$\bar{2}$}$$

Upon displacement of the observer from O to $\bar{O}$, h undergoes an apparent transverse percentage enlargement of

$$E_t = \bar{\beta}/\beta = D/\bar{D}, \tag{3}$$

and a an apparent axial percentage enlargement of

$$E_a = \bar{\alpha}/\alpha = D(D - a)/\bar{D}(\bar{D} - a). \tag{4}$$

Replacing $\bar{D}$ in (4) by its value from (3), we have

$$E_a = E_t \frac{D - a}{D/E_t - a}. \tag{5}$$

The viewing of an object in nature is thus subject to two simple rules (3) and (5).

To the naked eye, the only way to vary the apparent dimensions of an object is to approach it or withdraw from it; if, in the course of such a relocation of the observer, the angles at which he sees the transverse dimensions of the object have varied in a proportion E_t, the angles at which he sees an axial element a will have varied in a proportion E_a dependent upon E_t by the relation (5).

To determine what conditions must be met by a stereoscopic projection in order for the spectator to see any image whatsoever in natural relief (in the sense of our definition), we shall proceed as follows:

A spectator stationed at a distance D' from the projection screen sees a transverse element h'' of the image A' at an angle β'. We first inquire at what distance D from the object A one would have to be stationed in nature in order to see the transverse element h at an angle $\beta = \beta'$. From this distance D, we should see the axial element a at an angle α, and we must find under what conditions the spectator at distance D' from the screen will see the image of a at an angle $\alpha' = \alpha$. The latter equality must hold regardless of the value of a.

Let a photographic lens of focal length f_v be placed at a distance X_v from the object photographed; on the film, it projects an image h' of h such that

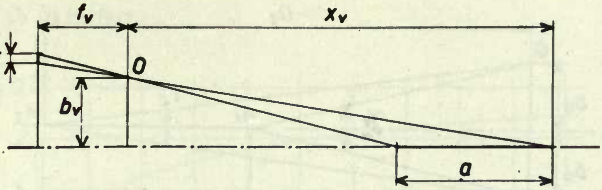

Figure 2.

$$h' = hf_v/X_v. \quad (6)$$

If a projection lens of focal length f_p projects this image h' on a screen placed at a distance X_p, the image h'' on the screen will have the dimension

$$h'' = h'X_p/f_p = hf_vX_p/f_pX_v. \quad (7)$$

A spectator stationed at a distance D' from the screen sees h'' at an angle β'

$$\beta' = h''/D = hf_vX_p/f_pX_v \cdot 1/D'. \quad (8)$$

The distance D at which one must be stationed to see h at the angle $\beta = \beta'$ in nature is given by

$$h/D = hf_vX_p/f_pX_v \cdot 1/D',$$

or $$D = f_pX_v/f_vX_p \cdot D'. \quad (9)$$

Consider a shot of the axial element a with a semibase b_v (Fig. 2).

$$k = af_vb_v/X_v(X_v - a). \quad (10)$$

Upon projection, we obtain an image k' of k on the screen:

$$k' = kX_p/f_p,$$

hence $$k' = af_vb_v/X_v(X_v - a) \cdot X_p/f_p. \quad (11)$$

The spectator sees k' at an angle α'

$$\alpha' = k'/D' = f_vX_p/f_pX_v \cdot 1/D' \cdot ab_v/(X_v - a). \quad (12)$$

We are to have $\alpha' = \alpha$, or

$$f_vX_p/f_pX_v \cdot 1/D' \cdot ab_v/(X_v - a) = ab_o/D(D - a). \quad (13)$$

The value of D is given by (9). Introducing this value of D into (13), we have

$$b_o/b_v = \frac{D'f_pX_v/f_vX_p - a}{X_v - a}. \quad (14)$$

The condition (14) must be satisfied for any value of a whatsoever, and the ratio b_o/b_v cannot vary with a. It is therefore necessary that $\partial(b_o/b_v)/\partial a = O$ no matter what a is, or that

$$X_v = D'f_pX_v/f_vX_p = O. \quad (15)$$

This relation (15) determines the value of D'

$$D' = X_pf_v/f_p. \quad (16)$$

Substituting this value of D' in (14),

$$b_o/b_v = 1, \quad b_o = b_v; \quad (17)$$

in (9), $$D = X_v; \quad (18)$$

in (8), $$\beta' = h/X_v; \quad (19)$$

and in (12) $$\alpha' - ab_v/X_v(X_v - a). \quad (20)$$

To summarize, the spectator receives the illusion of natural relief if the following two conditions are satisfied:

1. The camera base must be equal to the ocular base (relation 17);
2. The spectator must be stationed along the axis of projection at a distance from the screen which is to the projector-screen distance as the focal length of the camera lens is to the focal length of the projection lens (relation 16).

Relations (18), (19) and (20) show us that when conditions 1 and 2 above are satisfied, the spectator will see all the dimensions of the image at the same angles as the photographer saw the corresponding dimensions of the object while shooting.

Condition 1 is readily satisfied by construction; the camera must have a base between 63 and 67mm.

As for condition 2, it is to be noted

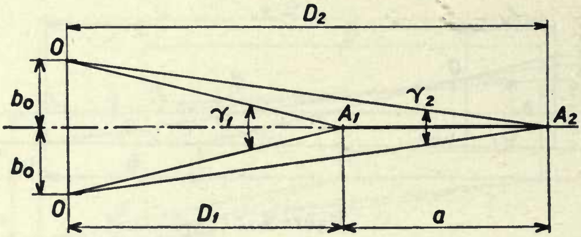

Fig. 3. Convergence and stereoscopic depth of field.

that this condition cannot be satisfied strictly for any spectator; for it is impossible to have the spectator's head on the axis of projection without casting a shadow on the screen. Still, it must be remembered that the closer the spectator is to the axis, the more closely the observed depth effect will approach natural relief. Again, if the spectator is not stationed at the distance D' from the screen as defined by (16), he will see a somewhat distorted relief. In particular, if the spectator is farther from the screen the image of an axial element a, or the segment transversely projected into k', will suffer an apparent enlargement E_a' equal to the apparent enlargement E_t' suffered by the image h'' of h. Upon projection, therefore, we have $E_a' = E_t' - 1$. In nature, if the observer had withdrawn from the object so that the transverse dimensions would suffer an enlargement $E_t = E_t'$, the axial element would have suffered an apparent enlargement.

$$E_a = E_t' \frac{D - a}{D/E_t' - a},$$

given by (5). Comparing E_a and E_a',

$$E_a/E_a' = \frac{D - a}{D/E_t' - a}.$$

Having assumed $E_t' - 1$, we have $D/E_t' - D$ and

$$E_a/E_a' - 1 \quad \text{or} \quad E_a' - E_a.$$

We can therefore conclude that if the spectator is farther from the screen, the depth of objects will be exaggerated, while if he is closer to the screen, the picture flattens.

The choice of focal lengths of cameras and projectors must be such that the largest possible number of spectators can be placed near the position of natural relief; this position should not be too close to the screen, since the spectators at optimum distance would then necessarily be fairly far away from the projector-screen axis.

Stereoscopic Depth of Field

Comfortable stereoscopic vision is impossible unless the extreme frontal planes of the object lie within two definite limits.

Let A_1 and A_2 be the intersections of the two extreme frontal planes of the object with the ocular axis of the eyes O, semibase b_o. The convergence is $\gamma_1 = 2b_o/D_1$ at A_1 and $\gamma_2 = 2b_o/D_2$ at A_2 (Fig. 3). For comfortable observation of the object, it is necessary that the maximum increment of convergence of visual rays, i.e. the difference $\gamma_1 - \gamma_2$, should not exceed a certain limiting value. This limiting value, unfortunately, varies from one observer to another; some people find a convergence differential of as little as 1° slightly troublesome, while others tolerate much higher differentials without fatigue. Since a stereoscopic film is to be viewed by numerous spectators, we must adopt a maximum value of $\gamma_1 - \gamma_2$ sufficiently small so that anyone may witness the performance without fatigue. At the same time, the limit must not be too

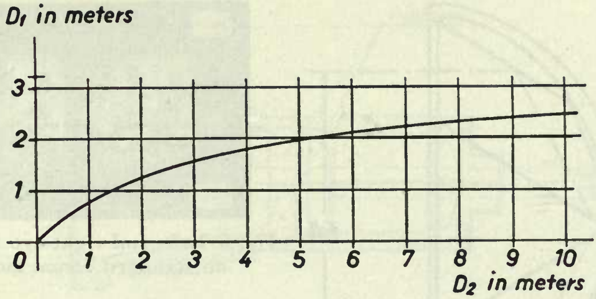

Fig. 4. Corresponding values of D_1 and D_2 for determining stereo depth of field.

low, so that photographic possibilities will not be excessively restricted. As the maximum convergence differential, we therefore take $\gamma_1 - \gamma_2 = 70'$; this value, which seems reasonable for practical purposes, is in accordance with the stereoscopic projection German Standard DIN 4531 (July 1949, Beuth-Vertrieb GmbH, Berlin W15 and Köln).

In the case of cinematographic equipment, when the camera base is equal to the ocular base, the convergence differential is the same for the spectator viewing the image a' at a distance $D' = X_p f_v / f_p$ from the screen and for the photographer viewing a in nature while shooting.

We may therefore say that D_1 and D_2 are the distances from the camera to the boundaries A_1 and A_2 of the subject, within which the photographer can shoot without exceeding a visual convergence of $\gamma_1 - \gamma_2$ for the spectator at distance D' from the screen.

We have

$$\gamma_1 - \gamma_2 - 2b_o(1/D_1 - 1/D_2),$$
$$1/D_1 - 1/D_2 = (\gamma_1 - \gamma_2)/2b_o. \tag{21}$$

If $\gamma_1 - \gamma_2 = 70' = 0.02$ radians and $2b_o = 64$mm,

we have $1/D_1 - 1/D_2 = 0.3125$ $\quad(\overline{21})$

when D_1 and D_2 are expressed in meters (Fig. 4).

For example, if we are to photograph a subject whose most distant part is at $D_2 = 5$ m from the camera, the relation $(\overline{21})$ shows us that no part of the scene photographed should then be less than $D_1 - 1.95$ m from the camera.

This limit on convergence differential therefore determines a maximum picture depth as a function of the range—a depth of field, called the stereoscopic depth of field.

Stereoscopic Depth of Field and Position of Projector Windows

In a stereoscopic projection, the field of the image projected is bounded laterally and vertically by the projector windows. The two projector windows form a stereoscopic pair, and depending on the lateral position of the windows with respect to the centers of the images photographed, the resultant image will be more or less distant from the spectator. For example, if the windows were centered with respect to the images of the points at infinity, along the axes of the camera lenses, the picture would seem to be located at infinity; with such a set-up we would always have $D_2 = \infty$, and no object could be photographed at less than $D_1 = 3.2$ m from the camera, otherwise the picture image would project beyond the stereoscopic depth of field.

Thus it turns out to be desirable to make the set-up such that the stereoscopic image of the projection windows seems to be an object located at 3.2 m from the camera. The frame then looks like

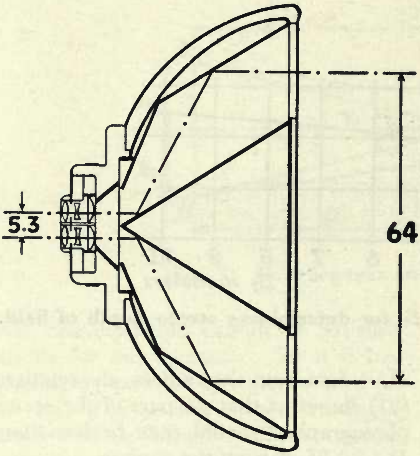

Fig. 5. Schematic diagram showing the path of rays through both openings at 64 mm, through prisms to the Yvar lenses, then on to 16mm film.

Fig. 6. Left- and right-eye Stereo images on standard 16mm movie film.

a window through which the spectator sees everything that has been photographed between 3.2 m and infinity.

Objects closer to the camera than this may be photographed. If the most distant plane of the subject is 3.2 m from the camera ($D_2 = 3.2$), objects as close as 1.6 m ($D_1 = 1.6$) may be filmed. The image will then seem to be between the window and the spectator, and precautions should be taken while photographing so that features situated in front of the window will not seem to be cut off by its edges.

In order to photograph at distances of less than 1.6 m, it would be necessary to change the position of the frame in order for the entire view to lie within the stereoscopic depth of field.

The Kern-Paillard Instrument

The photographic instrument has been built as an accessory for the H16 De Luxe Paillard Camera. It is a compact assembly screwed to the turret in place of an ordinary lens; it is automatically centered with respect to the axis of rotation of the turret, to prevent differences in height between the left-hand and right-hand images. The instrument comprises two Yvar lenses, $f = 12.5$mm, aperture 1/2.8, with parallel optical axes 5.3mm apart. The normal base of 64 mm is obtained by a system of prisms placed in front of the lenses (see Fig. 5).

The two homologous images are located side by side on the 16mm film, and together occupy one 16mm frame (see Fig. 6).

The lenses are universally focused and adjusted to their hyperfocal distance. If we assume a circle of diffusion of 1/50 mm on the film, the depth of field of definition is $\delta = 2.8/50 = 0.056$mm on the print. The hyperfocal distance is therefore

$$X = f^2/\delta = 156.25/0.056 = 2790\text{mm},$$

or 2.8 m. The lenses being adjusted for 2.8 m, good definition can be obtained from 1.4 m to infinity at full aperture. Now we have seen that the stereoscopic depth of field permits us to photograph from 1.6 m to infinity. The universal-focus lens adjusted to hyperfocal distance is thus adequate for all cases.

The projection instrument takes the place of the lens of a standard 16mm projector. It comprises 2 Petzval lenses, $f = 20$ mm, aperture 1/1.6, whose optical axes are parallel and 5.6 mm apart (Fig. 7); the projection windows are centered with respect to these axes. In front of each of these two lenses, there is a polarizer; the planes of polarization of

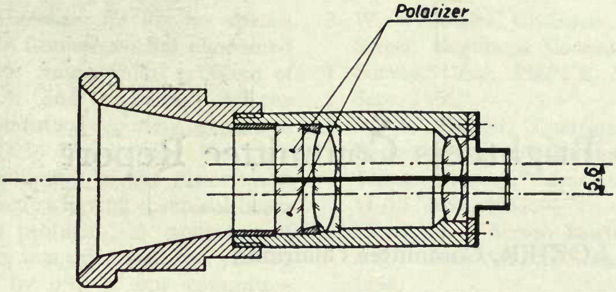

Fig. 7. Schematic drawing of projection lens, showing f:1.6 lenses of Petzval type and polarizing filters. The optical axes are separated by 5.6 mm.

the two polarizers are oriented at right angles and at 45° to the horizontal so that the film can be viewed with polarizing spectacles available on the market, for example Polaroid 3-D Picture Viewer. The projection screen must preserve the polarization of light. A metallized screen coated with an aluminum-base varnish is satisfactory.

We saw, in our discussion of stereoscopic depth of field, that the projection window should be located in space near a plane 3.2 m from the camera. Suppose we are photographing a point A at 3 m from the camera with camera lenses 5.3 mm apart, focal length 12.5 mm, base 64 mm. The two homologous images A' of A on the film will be

$$(64/3000)12.5 - 5.3 = 5.57$$

apart. The two projection windows should therefore be 5.57 mm or about 5.6 mm, between centers, in order for the plane of their stereoscopic image to appear to merge with the plane of A. The optical axes of the two projection lenses are likewise 5.6 mm apart. Under these circumstances, the planes at 3 m from the camera will coincide on the screen within 5.6 mm, regardless of the distance from the projector to the screen; it would be possible to eliminate the projection windows and bound the picture with the edges of the screen itself.

The choice of focal lengths of the camera and projector lenses places the spectator at a distance of

$$D' = (12.5/20)X_p = 0.625X_p$$

from the screen, or about two-thirds the screen-projector distance, for correct vision of the image.

Thus the Kern-Paillard instrument is a standard-base instrument in which judicious choice of focal lengths of camera and projector lenses affords vision approximating that of natural relief to a maximum number of spectators. The distances between the lenses are such that the image may be bounded either by means of the edges of the screen or by masking the projection lenses; in either case, the stereoscopic image appears to be bounded by a window about 3 m from the spectator. Anything photographed between 3 m and infinity appears behind this window; anything photographed between 1.5 m and 3 m appears between the window and the spectator. Photographing subjects closer than 1.5 m will result in emergence from the stereoscopic depth of field, and is inadvisable without the use of accessories which modify the convergence of axes and focusing of the Kern-Paillard system as they have been described in this article.

Screen Brightness Committee Report

By W. W. LOZIER, Committee Chairman

THE LAST REPORT of the Screen Brightness Committee presented at the April 1950 meeting of the Society[1] related a number of items receiving the attention of the committee. This report will summarize our progress to date and will outline some of our future plans.

1. Subcommittee on Meters and Methods of Measurement: This group under the chairmanship of F. J. Kolb, Jr., has made a thorough study of the measurement of screen brightness and related factors. Specifications have been set up on the range of the variables which will need to be covered by various types of instruments. The report by this Subcommittee has been accepted by the Screen Brightness Committee and recommended for early publication in the *Journal.*

2. Subcommittee on Projection Screens: This group under the chairmanship of Leonard Satz is engaged in the preparation of standards covering the brightness and whiteness characteristics of motion picture screens. The old War Standards of 1945 are being used as a basis of departure.

3. Subcommittee on Illumination Practices: This is a new group recently set up under the chairmanship of A. J. Hatch, Jr., for the purpose of establishing recommended practices concerning distribution of illumination on the motion picture screens.

Theater Survey of Screen Brightness: The Committee has completed a survey of screen brightness and related information in 125 indoor theaters widely distributed over the United States and in 18 West Coast studio review rooms used for viewing 35mm motion pictures. These data have been reported at the two 1951 meetings of the Society,[2,3] and have been published in the *Journal.* This survey has given us a good summary of screen illumination practices in a representative cross-section of the theaters in this country. This information is being used in our further activities looking toward improvement of theater screen illumination.

The Committee hopes to survey a number of representative outdoor theaters during 1953 to obtain information on screen illumination practices in these installations.

Revision of Screen Brightness Standard: The currently applicable American Standard on Screen Brightness, Z22.39-1944, has been modified[4] to include only indoor theaters and therefore exempts outdoor theaters from the provisions of this Standard. The revised standard has been recommended to the ASA for adoption as an American Standard.

Presented on October 9, 1952, at the Society's Convention at Washington, D.C., by W. W. Lozier, National Carbon Company, Division of Union Carbide and Carbon Corp., Fostoria, Ohio.

Preferred Conditions for Viewing Motion Pictures: Our Committee has concerned itself with the fundamental problem of determination and exposition of the preferred conditions for viewing motion pictures. The Committee has encouraged discussion of the history and important factors having technical bearing on this problem. A summary of these matters was published last year in the *Journal* by one of our committee members.[5]

The Committee arranged and sponsored a Symposium on Screen Viewing Factors at the Spring 1951 Convention of the Society. The papers presented at the symposium were published in the September 1951 *Journal*[6] and contain much information pertinent to the determination of preferred viewing conditions. There are indications that our efforts are bearing fruit and that new interest has been stimulated in the experimental determination of some of these factors and further important revelations can be expected.

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1. W. W. Lozier, Chairman, "Screen Brightness Committee Report," *Jour. SMPTE, 54:* 756–757, June 1950.
2. W. W. Lozier, Chairman, "Report on Screen Brightness Committee Theater Survey," *Jour. SMPTE, 57:* 238–246, Sept. 1951.
3. W. W. Lozier, Chairman, "Further Report on Screen Brightness Committee Theater Survey," *Jour. SMPTE, 57:* 11–15, Nov. 1951.
4. "Revision of Screen Brightness Standard," *Jour. SMPTE, 58:* 452, May 1952.
5. F. J. Kolb, Jr., "The scientific basis for establishing brightness of motion picture screens," *Jour. SMPTE, 56:* 433–442, April 1951.
6. Symposium on Screen Viewing Factors (6 papers), *Jour. SMPTE, 57:* 185–237, Sept. 1951.

The Committee

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Reaffirmation — PH22.50-1952
16mm Projector Reel Spindles

ASA rules require periodic review of all American Standards. In accord with this procedure, the 16mm and 8mm Motion Pictures Committee and the Standards Committee have recently reviewed Z22.50-1946 and reaffirmed it without change. The appropriate ASA committees have now approved this reaffirmation and the standard is therefore published on the following page as a validated 1952 standard.

American Standard

Reel Spindles

for 16-Millimeter Motion Picture Projectors

ASA
Reg. U. S. Pat. Off.
PH22.50-1952

1. Round Section

1.1 The round section of 16-mm motion picture projector reel spindles shall have a finished diameter of 0.312 ± 0.003 inch (7.925 ± 0.076 mm).

2. Square Section

2.1 The square section of 16-mm motion picture projector reel spindles, including finish, shall be 0.312 ± 0.003 inch (7.925 ± 0.076 mm) across the flats. Measurements across the flats shall be made in mutually perpendicular directions

3. Cumulative Effect of Eccentricity

3.1 The cumulative effect of eccentricity of the round and square sections of the spindles, looseness and misalignment of the bearing, or other mechanical imperfections shall not cause the flange of a tight-fitting reel to depart from the ideal plane by more than 40 minutes of arc

3.2 A suitable gage for determining the cumulative effect of eccentricity consists of a hub, with coaxial square and round holes whose respective sides and diameter are equal in length, and a flange of suitable stiffness whose diameter is equal to that of an 800-foot reel flange, 10.5 inches (266.7 mm). The flange should be permanently joined to the hub so that its face is perpendicular to the axis of the hub with not more than 0.003 inch (0.076 mm) runout. The hub shall be provided with a thumbscrew for clamping the hub to the reel spindle so that one side of the round and square holes shall come in contact with the corresponding round and square sections of the reel spindle.

4. Reel Position on Spindles

4.1 The design of spindles shall be such that reels are kept under constant lateral pressure against a shoulder on the spindle. The part forming this shoulder need not be integral with the spindle. However, in such event, it shall be securely fastened to the spindle so so that the two parts rotate together.

Approved March 19, 1946, by the American Standards Association

Standards PH22.5, PH22.12 and PH22.93 Related to 16mm and 35mm Low-Shrink Film

Two REVISED American Standards and one Proposed Standard are published on the following pages for three month trial and criticism. All comments should be sent to Henry Kogel, SMPTE Staff Engineer, prior to April 1, 1953. If no adverse comments are received, the three proposals will then be submitted to ASA Sectional Committee PH22 for further processing as American Standards.

The introduction of safety base of a low-shrink type removes some of the problems of film dimensions but has introduced two slight difficulties. To take care of these difficulties the Film Dimensions Committee has recommended modifications in the dimensional standards for 16mm film (PH22.5 and PH22.12) and has introduced a new standard (PH22.93) for 35mm film to be used as negative material on the sprocket-type printer.

In the case of 16mm film the introduction of low-shrink type base produced an increase in the number of cases where film has jammed in the camera gate. Investigation showed this increase to be due to the fact that many camera manufacturers had produced gates which would pass film only if the width of the film was appreciably less than the upper limit (0.630 in.) of the cutting and perforating tolerance. Now, the low-shrink type of film, even though originally slit within these tolerances, would swell at high humidities just as much as the older type with the result that its width at the time of use might well exceed the tolerance. This trouble rarely occurred with the older type of film because its characteristics were such that it would shrink enough by the time it reached the camera to compensate for any possible swelling at high humidities. The Committee recommends, therefore, an alternate standard slitting width of 0.628 in. ± 0.001 in. to be used with low-shrink film.

The Committee calls special attention to the fact that the act of writing the standard this way does not represent a decrease in the actual width of film as used by the customer. Manufacturers of apparatus should not use this change in dimension as a reason for changing the width of film gates.

In the case of 35mm film the same reasoning might apply but since no actual difficulties have been reported, the Committee does not wish to make a change in the nominal width of the film. Another difficulty, however, has been introduced. This difficulty occurs only on film which is to be used on sprocket type printers.

It will be recalled that the negative film on a sprocket-type printer must be shorter in pitch than the positive film if the two are to travel together around the sprocket without slippage relative to each other. For most printers this difference in length corresponds to a shrinkage of about 0.3%. Now, the negative film, such as was formerly used when nitrate film base was generally used, would shrink to approximately this value by the time it was ready for making release prints. Not much difficulty was encountered, therefore, arising from the slippage between nega-

tive and positive films on sprocket-type printers. With low-shrink safety base, however, sufficient shrinkage did not occur. It was found desirable, therefore, to "pre-shrink" the film by perforating it at a slightly shorter pitch than that previously used. The pitch selected was 0.1866 in. This is approximately 0.2% less than standard pitch instead of 0.3% as required by theory. It is found in practice, however, that this pitch produces satisfactory prints even when no shrinkage at all has occurred and still allows a margin for any shrinkage that is likely to occur later. It also introduces a minimum change in the action of the film in the camera. Tests have shown that cameras can take film of this pitch quite as well as film of the standard pitch.

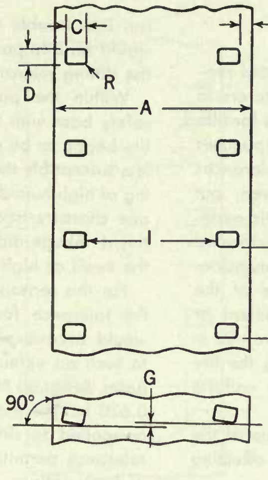
The case of master positive and duplicating negative is not completely solved by this new standard. Each one of these is used in the printer on the outside of the arc when the image is printed on to it and on the inside of the arc when the image is printed from it. No single pitch, therefore, can take care of both of these cases. In actual practice it is generally found satisfactory to use standard pitch for the master positive, short pitch for the duplicating negative and to do all the printing on continuous printers.—*E. K. Carver.*

Proposed American Standard

Dimensions for 16mm Double-Perforated Motion Picture Film

PH22.5

Revision of Z22.5–1947



Dimensions	Inches	Millimeters
*A	0.629 ± 0.001	15.98 ± 0.03
†B	0.3000 ± 0.0005	7.620 ± 0.013
C	0.0720 ± 0.0004	1.83 ± 0.01
D	0.0500 ± 0.0004	1.27 ± 0.01
*E	0.036 ± 0.002	0.91 ± 0.05
G	Not > 0.001	Not > 0.025
I	0.413 ± 0.001	10.490 ± 0.025
L‡	30.00 ± 0.03	762.00 ± 0.76
R	0.010	0.25

These dimensions and tolerances apply to negative and positive raw stock immediately after cutting and perforating.

*For low-shrink film as defined in Appendix 2, A shall be 0.628 ± 0.001 and E shall be 0.0355 ± 0.0020 in.

†In any group of four consecutive perforations, the maximum difference of pitch shall not exceed 0.001 in. and should be as much smaller as possible.

‡This dimension represents the length of any 100 consecutive perforation intervals.

NOT APPROVED

Proposed American Standard
Dimensions for 16mm Double-Perforated Motion Picture Film

PH22.5

Revision of Z22.5–1947

Appendix 1

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but owing to the fact that film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the punches and dies. Shrinkage of the film, due to change in moisture content or loss of residual solvents, invariably results in a change in these dimensions during the life of the film. This change is generally uniform throughout the roll.

The uniformity of perforation is one of the most important of the variables affecting steadiness of projection.

Variations in pitch from roll to roll are of little significance compared to variations from one sprocket hole to the next. Actually, it is the maximum variation from one sprocket hole to the next within any small group that is important. This is one of the reasons for the method of specifying uniformity in dimension B.

Appendix 2

In the early days of 16mm film the safety base used for this film had the characteristic of shrinking very rapidly to a certain fairly definite amount and then not shrinking much more. Although this film tended to swell at high humidities, nevertheless the shrinkage that occurred in the package before the user received the film was always at least as great as any swell that might occur due to high humidities at the time of use. This meant that the user never encountered film, even at high humidities, that had greater width than that specified in the standards. This meant that camera and projector manufacturers seldom ran into trouble so long as their film gates would readily pass film at the upper limit of the slitting tolerances, namely 0.630 in.

Within the past few years, however, a safety base with lower shrinkage characteristics began to be used. Although this film was less susceptible than the previous film to swelling at high humidities, nevertheless the shrinkage characteristics were low enough so that this shrinkage did not always compensate for the swell at high humidities.

For this reason film slit at the mid point of the tolerance for width, namely 0.629 in., would occasionally swell at high humidities to such an extent that it would bind in film gates designed to pass film with the width of 0.630 in. The manufacturers, therefore, were compelled to slit at the lower edge of the tolerance permitted by the American Standard. Variations in their slitting width, however, sometimes produced film slit below the limits of the standard.

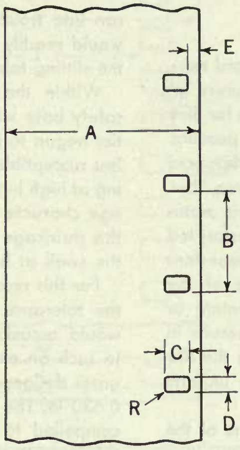
For this reason an alternate standard has been adopted for this low-shrink film in order that the manufacturers may slit within the standard and still produce film which does not exceed 0.630 in. even at high humidities.

For the purpose of this specification, low-shrink film base is film base which, when coated with emulsion and any other normal coating treatment, perforated, kept in the manufacturer's sealed container for 6 months, exposed, processed, and stored exposed to air not to exceed 30 days at 65 to 75 F and 50 to 60% relative humidity and measured under like conditions of temperature and humidity, shall have shrunk not more than 0.2% from its original dimension at the time of perforating. The final measurement should be made after conditioning the film for 24 hours to a humidity of 55 ± 5%.

This definition of low-shrink film is to be used as a guide to film manufacturers, and departure therefrom shall not be cause for rejection of the film.

NOT APPROVED

Proposed American Standard # Dimensions for 16mm Single-Perforated Motion Picture Film	PH22.12 Revision of Z22.12–1947



Dimensions	Inches	Millimeters
*A	0.629 ± 0.001	15.98 ± 0.03
†B	0.3000 ± 0.0005	7.620 ± 0.013
C	0.0720 ± 0.0004	1.83 ± 0.01
D	0.0500 ± 0.0004	1.27 ± 0.01
*E	0.036 ± 0.002	0.91 ± 0.05
L‡	30.00 ± 0.03	762.00 ± 0.76
R	0.010	0.25

These dimensions and tolerances apply to negative and positive raw stock immediately after cutting and perforating.

*For low-shrink film as defined in Appendix 2, A shall be 0.628 ± 0.001 and E shall be 0.0355 ± 0.0020 in.

†In any group of four consecutive perforations, the maximum difference of pitch shall not exceed 0.001 in. and should be as much smaller as possible.

‡This dimension represents the length of any 100 consecutive perforation intervals.

NOT APPROVED

Proposed American Standard
Dimensions for 16mm Single-Perforated Motion Picture Film

PH22.12

Revision of Z22.12–1947

Appendix 1

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but owing to the fact that film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the punches and dies. Shrinkage of the film, due to change in moisture content or loss of residual solvents, invariably results in a change in these dimensions during the life of the film. This change is generally uniform throughout the roll.

The uniformity of perforation is one of the most important of the variables affecting steadiness of projection.

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For this reason film slit at the mid point of the tolerance for width, namely 0.629 in., would occasionally swell at high humidities to such an extent that it would bind in film gates designed to pass film with the width of 0.630 in. The manufacturers, therefore, were compelled to slit at the lower edge of the tolerance permitted by the American Standard. Variations in their slitting width, however, sometimes produced film slit below the limits of the standard.

For this reason an alternate standard has been adopted for this low-shrink film in order that the manufacturers may slit within the standard and still produce film which does not exceed 0.630 in. even at high humidities.

For the purpose of this specification, low-shrink film base is film base which, when coated with emulsion and any other normal coating treatment, perforated, kept in the manufacturer's sealed container for 6 months, exposed, processed, and stored exposed to air not to exceed 30 days at 65 to 75 F and 50 to 60% relative humidity and measured under like conditions of temperature and humidity, shall have shrunk not more than 0.2% from its original dimension at the time of perforating. The final measurement should be made after conditioning the film for 24 hours to a humidity of 55 ± 5%.

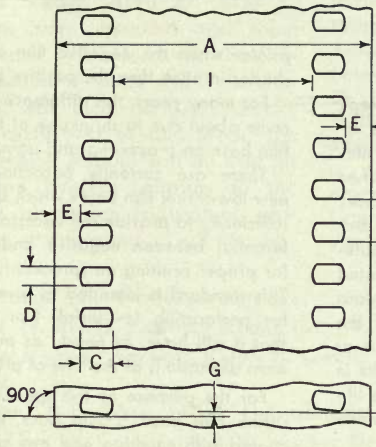
This definition of low-shrink film is to be used as a guide to film manufacturers, and departure therefrom shall not be cause for rejection of the film.

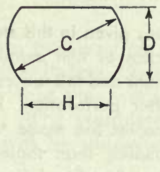
NOT APPROVED

Proposed American Standard

Dimensions for 35mm Motion Picture Short-Pitch Negative Film

PH22.93





Dimensions	Inches	Millimeters
A	1.377 ± 0.001	34.98 ± 0.03
B	0.1866 ± 0.0005	4.740 ± 0.013
C	0.1100 ± 0.0004	2.794 ± 0.01
D	0.073 ± 0.0004	1.85 ± 0.01
E	0.079 ± 0.002	2.01 ± 0.05
G	Not > 0.001	Not > 0.025
*H	0.082	2.08
I	0.999 ± 0.002	25.37 ± 0.05
L‡	18.66 ± 0.015	474.00 ± 0.38

These dimensions and tolerances apply to low-shrink negative raw stock immediately after cutting and perforating.

This film is used for motion picture negatives and certain special processes.

* A calculated value for a dimension not measured routinely in production.

‡ This dimension represents the length of any 100 consecutive perforation intervals.

This standard is based on American Standard Z22.34–1949 and differs only in the values of B and L and the addition of a second Appendix.

NOT APPROVED

Proposed American Standard

Dimensions for 35mm Motion Picture Short-Pitch Negative Film

PH22.93

Appendix 1

The dimensions given in this standard represent the practice of film manufacturers in that the dimensions and tolerances are for film immediately after perforation. The punches and dies themselves are made to tolerances considerably smaller than those given, but owing to the fact that film is a plastic material, the dimensions of the slit and perforated film never agree exactly with the dimensions of the punches and dies. Shrinkage of the film, due to change in moisture content or loss of residual solvents, invariably results in a change in these dimensions during the life of the film. This change is generally uniform throughout the roll.

The uniformity of perforation is one of the most important of the variables affecting steadiness of projection.

Variations in pitch from roll to roll are of little significance compared to variations from one sprocket hole to the next. Actually, it is the maximum variation from one sprocket hole to the next within any small group that is important.

Appendix 2

Most motion picture film is printed on sprocket-type printers. Maximum steadiness and definition are secured on a sprocket-type printer when the negative film is somewhat shorter in pitch than the positive stock.

For many years, this difference in pitch has come about due to shrinkage of the negative film base on processing and aging.

There are currently becoming available new low-shrink film bases which do not shrink sufficiently to provide the necessary pitch differential between negative and print stock for proper printing on sprocket-type printers. This standard is intended to give dimensions for perforating low-shrink film material so that it will have, as nearly as possible, optimum dimensions at the time of printing.

For the purpose of this specification, low-shrink film base is film base which, when coated with emulsion and any other normal coating treatment, perforated, kept in the manufacturer's sealed container for 6 months, exposed, processed, and stored exposed to air not to exceed 30 days at 65 to 75 F and 50 to 60% relative humidity and measured under like conditions of temperature and humidity, shall have shrunk not more than 0.2% from its original dimension at the time of perforating. The final measurement should be made after conditioning the film for 24 hours to a humidity of 55 ± 5%.

This definition of low-shrink film is to be used as a guide to film manufacturers, and departure therefrom shall not be cause for rejection of the film.

NOT APPROVED

73d Semiannual Convention

A meeting of the Papers Committee at Washington on October 9, during the 72d Convention, laid general plans for the Spring Convention to be held at the Los Angeles Statler, April 27 – May 1. Several aims were espoused and some sessions planned. Inasmuch as the National Association of Radio and Television Broadcasters will meet at Los Angeles during the early part of that week, the SMPTE television sessions will be held on Thursday and Friday, contrary to the arrangement of recent convention programs. The arrangement of all the sessions will be shown in the Advance Notice of the Convention scheduled to be mailed to members on March 2d.

Deadlines established by Papers Committee Chairman Bill Rivers and 73d Program Chairman Ralph Lovell are: Authors' Forms and Abstracts due on February 16; manuscripts due on March 23.

Blank forms can now be obtained from anyone on the Papers Committee, but it is preferable that you work with the one nearest you. The complete roster of the Committee will be published in the next *Journal*.

The Chairman and Vice-Chairmen are:

Chairman: W. H. Rivers, Eastman Kodak Co., 342 Madison Ave., New York 17.

73d Convention Program Chairman: Ralph E. Lovell, 2743 Veteran Ave., West Los Angeles 64, Calif.

For Washington: J. E. Aiken, 116 N. Galveston St., Arlington 3, Va.

For Chicago: Geo. W. Colburn, 164 N. Wacker Dr., Chicago 6, Ill.

For High-Speed Photography: Carlos H. Elmer, 410B Forrestal St., China Lake, Calif.

For Canada: G. G. Graham, National Film Board of Canada, John St., Ottawa, Canada.

For New York: E. Arthur Hungerford, Jr., Campfire Rd., Chappaqua, N.Y.

Awards

The Society serves its field in one way, among others, by an attempt to recognize formally important contributions by individuals. Several awards are conferred annually upon those whose work has been considered significant in their particular fields of interest. Those who were selected during 1952 were presented awards during the Fall Convention of the Society in Washington, D.C. Their names and awards are listed here.

As has been done in past years there were published earlier this year, in April, the recommendations, citations and former recipients of the Progress Medal Award, the Samuel L. Warner Memorial Award, the Journal Award and the David Sarnoff Award.

New Fellows of the Society

President Mole formally inducted the following as new Fellows of the Society:

John Arnold, Metro-Goldwyn-Mayer Studios, Culver City, Calif.

E. E. Blake, Council Kinematograph Manufacturers Association of Great Britain and Kodak Ltd., London

O. L. Dupy, Metro-Goldwyn-Mayer Studios, Culver City, Calif.

Karl Freund, Photo Research Corp., Burbank, Calif.

Edgar Gretener, Dr. Edgar Gretener A.G., Zurich, Switzerland

W. T. Hanson, Jr., Eastman Kodak Co., Rochester, N.Y.

C. E. Heppberger, National Carbon Co., Chicago

President Peter Mole is at the left. Award recipients next in order shown are: Axel G. Jensen, the David Sarnoff Gold Medal Award; Wadsworth Pohl who accepted the Samuel L. Warner Memorial Award on behalf of Herbert T. Kalmus; John I. Crabtree, the Progress Medal; and D. L. MacAdam, the Journal Award.

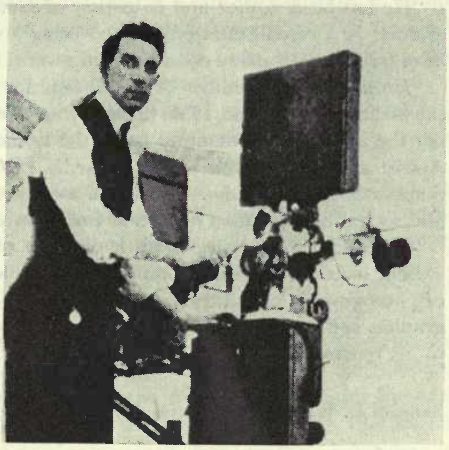
Henry J. Hood, Eastman Kodak Co., Rochester, N.Y.
A. G. Jensen, Bell Telephone Laboratories, Murray Hill, N.J.
Klaus Landsberg, KTLA Television Productions, Hollywood, Calif.
E. H. Reichard, Consolidated Film Industries, Hollywood, Calif.
A. C. Robertson, Eastman Kodak Co., Rochester, N.Y.
Ben Schlanger, Consultant, New York
John G. Stott, Du-Art Film Laboratories, New York
E. W. Templin, Westrex Corp., Hollywood, Calif.

Journal Awards

The Journal Award went to D. L. MacAdam of the Research Laboratory, Eastman Kodak Co., Rochester, N.Y., for his "Quality of Color Reproduction" which was published in May 1951.

Franklin C. Williams of the Research Laboratory, Eastman Kodak Co., Rochester, N.Y., received honorable mention for his "Current Problems in the Sensitometry of Color Materials and Processes" which appeared in the *Journal* for January 1951.

Honorable mention was conferred on Otto H. Schade, Tube Dept., Radio Corporation of America, Harrison, N.J., for "Image Gradation, Graininess and Sharpness in Television and Motion Picture Systems — Part I: Image Structure and Transfer Characteristics" which appeared in the February 1951 *Journal*.



William C. Kunzmann who has been Convention Vice-President since time memorial of this Society was presented a gold card of Life Membership "in grateful recognition of 36 years of enthusiastic participation and inspired leadership in the work of the Society." Shown in the usual order are Editorial Vice-President John Frayne, Bill Kunzmann and President Peter Mole. Next are pictures salvaged from old lantern slides depicting Bill and his activities at a somewhat earlier stage of his career.

New Society Formed

At a meeting at the Hotel Astor, New York, October 2nd, 3rd and 4th, the Society of Motion Picture Engineers was formed. The membership includes men who are closely connected with the development of the engineering and of motion picture work and the society has for its main object the standardization of the industry. W. C. Kunzman of the Sales Department is a member of the Committee on Illumination Development. At the organization meeting C. Francis Jenkins, of Washington, D. C., was elected president. The next meeting of the society will be held at Atlantic City some time in March, at which a number of papers will be presented.

Progress Medal

John I. Crabtree, head of the photographic chemistry department of Kodak Research Laboratories, received the Progress Medal "for his outstanding contribution in the field of photographic chemistry, motion picture processing and processing equipment." The formal presentation was made by D. B. Joy, Chairman of the Progress Medal Award Committee, as follows:

"He was born and educated in England and started his professional work as a Research Chemist with the Eastman Kodak Company in Rochester in 1913. He became a naturalized United States citizen in 1924. He founded the photographic chemistry department of Kodak Research Laboratories in 1913 and is still its head. From 1916 to 1938 he also was in charge of the motion picture film developing department. He has conducted and supervised research in many fields of photography including the chemistry of development and fixation, methods of processing photographic materials, the use of desensitizers, stains and markings on photographic materials, preparation and use of flash powders, tinting and toning of lantern slides and motion picture films, the corrosive effect of photographic solutions on photographic apparatus, tropical processing, silver recovery, compounding of package chemicals, storage of photographic records, and effective methods of washing photographic materials. He has devoted much of his attention to the technique of motion picture processing.

"A particularly important piece of research concerned the chemistry of the stop bath and especially of the fixing bath. Recent very valuable work has been done in his department on agents for "sequestering" calcium and iron in developers, on replenishment systems for developers, on rapid processing at high temperatures, on the preparation of concentrated liquid developers, and on the design of special processing equipment.

"He has been author and co-author of some 150 papers and two books and has been granted 30 United States patents, covering a wide variety of subjects. His articles have been published in many countries and several have been reprinted as handbooks.

"He has been a member of this Society for more than 25 years. He was President of the Society in 1930 and 1931, during which time he was largely instrumental in establishing the *Journal* on a monthly basis, the system of Sustaining Memberships, the Journal Award and this Progress Medal Award. His vivid discussions of papers have enlivened many a Society Meeting. He was a member of the Board of Governors for many years and served as Chairman of several committees and of the Board of Editors.

"He has been an active member of many other scientific societies.

"For nearly forty years, John I. Crabtree has worked diligently at his chosen profession of photographic chemistry. Much of the advancement of knowledge of general photographic and motion picture processing reactions and techniques can be traced directly to his researches and that of colleagues under his supervision."

Samuel L. Warner Memorial Award

Herbert T. Kalmus, President and General Manager of Technicolor Motion Picture Corp., was awarded the Samuel L. Warner Memorial Award. President Mole first spoke of the awarding as follows:

"As one who comes from Hollywood, I am taking the liberty of saying a few words of my own on this award. In the early twenties, an obscure scientist was struggling in Boston to perfect a color formula for motion picture film which was destined one day to revolutionize the motion picture industry. This scientist, against innumerable odds and financial setbacks, was persistent, however, and finally conquered these obstacles to give to the world of motion pictures natural color as we know it today — Technicolor.

"For bringing color to motion pictures, Herbert Kalmus must be credited as one of the savers of the motion picture boxoffice. Color came at a time when the public was tiring

of black-and-white films and both producers and exhibitors needed something new to attract patrons to the theater. As one who richly deserves this high honor from our Society, Dr. Herbert T. Kalmus now receives the Samuel L. Warner Memorial Award, accepted on his behalf by Mr. Wadsworth Pohl, his associate."

The citation prepared by the Committee, of which Glenn L. Dimmick is Chairman, was as follows:

"No man, over the past 20 years, has so consistently contributed to the technical quality of motion pictures as Dr. Herbert T. Kalmus. Almost without exception, the biggest grossers since *Gone With the Wind* have been pictures made in 'Color by Technicolor.' Indeed, good color of any type, in the eyes of the public, is called Technicolor. It is today the standard by which other color processes are judged.

Dr. Kalmus, over the years, has maintained the highest practicable color standards and has always recognized the value of research and engineering toward this end. While maintaining these standards of quality, the cost of not only release prints but set lighting costs have been reduced step by step as faster-type emulsions were made available to picture producers. During the last war, Technicolor's ability to 'blow up' the 16mm Kodachrome footage of the Armed Forces to 35mm film for showing to the public in theaters was a great aid to morale and public information in those critical times. If it had not been for the war and its retarding effect on civilian development, Technicolor's single-film Monopack would have been available sooner to supplant the three-negative process. Dr. Kalmus hoped as early as 1940 to bring it into wide use and its availability will undoubtedly be greater in the immediate future.

"Technicolor's perfection in the last few years of the inbibition process of making top quality 16mm color prints in quantity at reasonable cost is a distinct contribution to the 16mm field. The quality of both picture and sound of these prints and the development of the techniques of making the separate sound negatives for mass production by the 35mm32mm method contributes a great deal to the excellence of the 16mm sound.

"Dr. Kalmus, through his personal and active direction of his company, has been instrumental in creating the boxoffice truism that 'good color makes a good picture a still better picture.'

"For further information on Dr. Kalmus, I refer to the article in the Saturday Evening Post of October 22, 1949, 'Mr. Technicolor,' by Frank J. Taylor. Dr. Kalmus was given the Society's Progress Medal for 1938 and the citation was presented on pages 556 to 560 of the December 1938 *Journal*."

David Sarnoff Gold Medal Award

Axel G. Jensen was presented the David Sarnoff Gold Medal Award "for his manifold contributions to the promulgating of monochrome and color television engineering standards, and for his work on the improvement of the quality of television pictures obtained from motion picture film." Pierre Mertz was Chairman of the Committee which made this citation:

"Axel G. Jensen was born and educated in Copenhagen, Denmark, until coming to Columbia University in 1921 for graduate work.

"His professional career began in 1922 when he joined what is now the Research Department of the Bell Telephone Laboratories. Since 1938 he has been engaged in research work in television equipment and systems. In particular he has been responsible for the development of a high-quality testing link which, employing motion picture film, can be used as a research tool for the evaluation of methods and systems for television transmission, and of the influence of component elements on the transmission quality. As a part of this he has been in charge of work on a succession of test film scanners, culminating in a development which was presented before the Society last year. He has

also been responsible for considerable miscellaneous research work on electrical, optical and visual problems connected with television systems.

"Mr. Jensen has taken part in many industry committees, particularly many committees promulgating engineering standards for television as a result of their deliberations. He took an active part in the committee work of the first NTSC in 1941, from which came the engineering standards in monochrome television which are still largely in use today. He continued to take an active part in the television activities of RTPB from 1944 to 1948, and of panels of JTAC. In the second NTSC, established in 1950, he has been a member of several panels and is now vice-chairman of Panel 12 on Color System Analysis. He has been chairman of the IRE-RTMA-SMPTE Television Coordinating Committee in 1950–51; vice-chairman of the IRE Standards Committee in 1949–50, and chairman in 1951; chairman of the IRE Television Committee in 1948; and chairman of the IRE Television Systems Committee in 1949–51. He was elected a Fellow of the IRE in 1942, and Governor of the SMPTE in 1952. He has just finished an extensive lecture tour, in the United States and Europe, describing the fundamentals of color television transmission and of the various systems which can be used to achieve it. In the course of it he was awarded the G. A. Hagemann Gold Medal by the Royal Technical University of Denmark.

"In the Bell Telephone Laboratories Mr. Jensen has recently been promoted from Engineer in Charge of Television Research, to Director of Television Research. He holds ten issued patents and has published a number of papers, the most recent being, in coauthorship with R. E. Graham and C. F. Mattke, on a "Continuous Motion Picture Projector for Use in Television Film Scanning," in the January 1952 *Journal*."

Board of Governors Meeting

Meeting on October 5 at Washington, the Board gave a considerable portion of its attention to information from the Executive Committee, reported by Executive Vice-President Barnett and Executive Secretary Nemec.

The publication of proposed amendments to the Bylaws in the August Journal was noted. (These were voted approved at the Society's Business Meeting on October 6.) Plans for continued study of test film costs were briefly discussed and the Society's success in restoring the mailing of the *Journal* to the proper (lowest cost) category was noted.

A lively, detailed and constructive discussion about membership service quality, costs and promotion held the Board's attention for nearly two hours, with every officer and governor contributing reports of the needs of television, film producer, high-speed photography and other interests. Specific suggestions in the notes for follow-up by the staff were tabbed as from Messrs. Aiken, D'Arcy, Heppberger, Mole, Neu, Shaner, Sponable, Stifle and Townsley. (Material helpful to television engineers has since been planned. The complete roster of member and nonmember high-speed photography registrants has been mimeographed and circulated to the High-Speed Photography Committee for their help in obtaining new members. The brochure describing the Society for prospective members is now revised.) A six-page membership cost study was read by Executive Secretary Nemec on behalf of the Executive Committee. This study was accepted as the record of the past three years and as a basis for a continuing record and guidance for the Board.

Reports by the respective vice-presidents were welcomed and approved as in good order by the Board.

A change in the Administrative Practices was approved as presented as follows in the report by Editorial Vice-President Frayne:

"Because the Board of Editors as presently comprised of 18 members is no more than adequate, the Administrative Practices should be brought up to date by changing the present stipulation of 'seven Fellows and Active members,' to: 'The Editorial Vice-President upon taking office shall appoint the chairman of the Board of Editors and the members of the Board. The latter shall consist of not less than 12 members of the Society in good standing and shall be representative of all the various branches and interests of the motion picture and television industry.' "

Reports of Section Chairmen Heppberger, Shaner and Stifle contained a new element in greater strength: regional organizations established at San Francisco and Dallas and proposed in Atlanta. (A report of the San Francisco Subsection has been given in the October 1952 *Journal* and a brief report of the Atlantic Coast Section Regional Meeting was published in the September 1952 *Journal*.)

New Officers

At the close of the October 5 Board Meeting, Secretary Robert M. Corbin reported the results of the Society election for 1952. The following were elected for two-year terms beginning January 1, 1953:

Herbert Barnett, President
John G. Frayne, Executive Vice-President
Norwood L. Simmons, Editorial Vice-President
John W. Servies, Convention Vice-President
Edward S. Seeley, Secretary
Frank E. Carlson, Governor, Central
Gordon A. Chambers, Governor, East
LeRoy M. Dearing, Governor, Pacific
William A. Mueller, Governor, Pacific
Charles L. Townsend, Governor, East
Malcolm G. Townsley, Governor, Central

By action of the Board of Governors during its previous meeting in July, Henry Hood was appointed to fill a vacancy in the office of Engineering Vice-President that was created by the resignation of F. T. Bowditch. Henry's term extends to December 31, 1953.

The Section elections made the following officers and new members of the Board of Managers:

Atlantic Coast Section

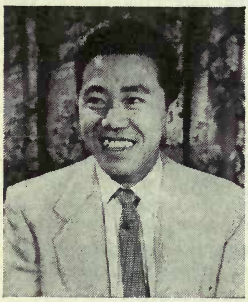
William H. Offenhauser, Jr., Chairman
Emerson Yorke, Secretary-Treasurer
Russell C. Holslag, Manager, 1953–1954
Milton H. Searle, Manager, 1953–1954
R. T. Van Niman, Manager, 1953–1954

Central Section

C. E. Heppberger, Chairman, reelected
James L. Wassell, Secretary-Treasurer, reelected
Paul Ireland, Manager, 1953–1954
William P. Kusak, Manager, 1953–1954
John S. Powers, Manager, 1953–1954

Pacific Coast Section

Vaughn C. Shaner, Chairman, reelected
Philip G. Caldwell, Secretary-Treasurer, reelected
Ralph Lovell, Manager, 1953–1954
Hollis Moyse, Manager, 1953–1954
Herbert Pangborn, Manager, 1953–1954



K. Kenneth Miura

The Student Chapter at the University of Southern California earlier this year elected K. Kenneth Miura its Chairman, and Richard Polister its Secretary-Treasurer.

Richard Polister

Organization of the Southwest Subsection

Activities of the recently formed Southwest Subsection began formally on the evening of October 23 in the studios of WBAP-TV, Fort Worth, Texas. C. E. Heppberger presided over the meeting and advised about the operation of a subsection. There were present 13 members and 23 guests.

Elected as the subsection's first roster of officers were:

Bruce Howard, Chairman;
Hugh V. Jamieson, Jr., Vice-Chairman and Secretary-Treasurer;
I. L. Miller, Program Chairman; and
George Mayer, Membership Chairman.

Future meetings are tentatively scheduled:

January 16, Friday evening, in Dallas;
March 16, Monday evening, in Fort Worth; and
May 20, Wednesday evening, in Dallas.

Members will be advised by letter confirming the dates and exact place of the meetings.—*Hugh V. Jamieson, Jr.*, 3825 Bryan St., Dallas 4, Tex.

Engineering Activities

72d Convention This is a continuation of the report on the meetings of Engineering Committees at the 72d Convention in Washington, D.C. See the November 1952 *Journal* for the first part of this story.

16mm and 8mm Motion Pictures Six American Standards, listed below, have been under active review for some time:

PH22.9, 16mm Double-Perforated Motion Picture Film — Usage in Camera;
PH22.10, 16mm Double-Perforated Motion Picture Film — Usage in Projector;
PH22.15, 16mm Single-Perforated Motion Picture Film — Usage in Camera;
PH22.16, 16mm Single-Perforated Motion Picture Film — Usage in Projector;
PH22.21, 8mm Motion Picture Film — Usage in Camera;
PH22.22, 8mm Motion Picture Film — Usage in Projector.

At this meeting it was agreed to draft further revisions of the first two standards, eliminate "guided edge" specification from the next two standards, and approve the last two standards without further change.

The ballot on the proposed standard, A and B Windings of 16mm Raw Stock Film, PH22.75, was reported as virtually complete without any negative votes. The ballot was therefore closed with an affirmative recommendation to the Standards Committee for further processing as an American Standard.

Magnetic Recording Subcommittee The widespread development and use of magnetic sound tracks demand a companion test film and standards program. Such a program, under way for some time, has now been launched with full force.

The magnetic recording proposals for 16mm and 35mm–17½mm film, PH22.86 and PH22.87, have cleared all the appropriate Society committees and are presently under review by ASA Sectional Committee PH22.

Agreement was reached on the dimensions of the magnetic coating of the 8mm proposal, PH22.88, for immediate consideration by the Sound Committee.

Similar approval was given to five proposed standards on magnetic test films, listed below:

SMPTE 509, 16mm Magnetic Flutter Test Film;
SMPTE 510, 35mm and 17½mm Magnetic Flutter Test Film;
SMPTE 511, Azimuth Alignment Test Film for 17½mm and 35mm Film With Magnetic Coating;
SMPTE 512, Azimuth Check Loop on 17½mm and 35mm Film With Magnetic Coating;
SMPTE 513, Azimuth Test Film for Fully Coated Magnetic 16mm Single-Perforated Motion Picture Film.

A subcommittee was then formed to study existing magnetic recording equipment with a view toward standardizing the reproducer characteristics.

Finally, with an eye toward the future, attention was called to the potentialities of half photographic/half magnetic track on 16mm film and magnetic track substituted for photographic on 35mm film.

Sound This meeting followed on the heels of the above Subcommittee meeting but in actuality the two meetings were held jointly. The Sound Committee now approved for letter ballot the six proposals approved by the Subcommittee and a seventh on 200-mil magnetic coating of 16mm single perforated film (SMPTE 544) submitted by the Subcommittee some time prior to this meeting.

In addition it was agreed to revise the three test film standards listed below. The revision would permit elimination of the identification leader and substitution of titles printed lengthwise in the picture area. This would increase the usable test film footage by about 25% without increasing its cost.

Z22.42-1946, 16mm 5000- and 7000-Cycle Sound Focusing Test Films;
Z22.45-1946, 16mm 400-Cycle Signal Level Test Films;
Z22.57-1947, 16mm Buzz Track Test Films.

Stereo This committee was formed in March 1952 with immediate attention devoted to development of a standard nomenclature and compilation of a bibliography. Prior to this first meeting the committee was very active in nomenclature activity via the mails. The entire meeting was therefore devoted to reviewing this activity and working out word for word the meanings of some of the more controversial, complex terms.

In briefly commenting on the bibliography project, John Norling, Chairman, stated that progress was being made and that a first draft would soon be issued to the committee for review.

Television Film Equipment This meeting had been called for only one reason: to expedite action on dimensional standards for the recorded and reproduced area of televised motion pictures. Differences had developed between East and West Coast thinking on this question which had prevented standardization to date.

The advantages and disadvantages of both proposals were thoroughly aired and a compromise proposal was offered for consideration. It was finally agreed to submit the latter proposal for letter ballot of the full committee. The vital dimensions of all three proposals are:

35 mm	*Record*	*Reproduce*
East	.609 × .812	.582 × .776
West	.619 × .825	.600 × .800
Compromise	.612 × .816	.594 × .792
16mm		
East	.288 × .384	.270 × .360
West	.288 × .384	.279 × .372
Compromise	.285 × .380	.276 × .368

Color This was the first meeting of this committee under its new Chairman, Dr. J. P. Weiss. The committee reviewed the state of the art and concluded that color was still in the early stages of development, which precludes any standards work at this time. It was noted, however, that comprehensive reports on various aspects of the field — for example, the published report "Principles of Color Sensitometry" — are considered very useful and desirable, and plans were made to further stimulate such activity.

High-Speed Photography A high priority was given to the question of developing a dictionary of terms peculiar to high speed photography and a subcommittee headed by Morton Sultanoff was appointed to begin active work on this.

The ASA Exposure Index also came up for discussion and it was considered highly desirable to extend film ratings to cover the range of exposures from a millisecond to a microsecond. This is no simple matter and the question was referred to ASA Sectional Committee PH2 for study and action.

The meeting closed with Carlos Elmer accepting the responsibility of the high-speed photography papers program for the Spring Convention in Los Angeles.

Meeting Reports For those who are interested in more detailed information concerning any of the above reported engineering committee meetings, a copy of the particular meeting report is available upon request.—*Henry Kogel*, Staff Engineer.

Book Reviews

Storage Tubes and Their Basic Principles

By M. Knoll and B. Kazan. Published (1952) by John Wiley, 440 Fourth Ave., New York 16. 143 pp. 34 illus. 6 × 9 in. Price $3.00.

Presumably the first text devoted exclusively to storage tubes, this book is useful to anyone concerned with the field. Of particular interest to television and motion picture engineers is the treatment of the iconoscope, the image orthicon and their relatives as particular cases of the genus storage-tube.

The writers first treat fundamentals, the electron bombarded "floating" surface, then definitions and basic operational methods. This is followed by a lucid treatment of the details of 23 individual storage tubes, suitably classified as to type. Ninety-nine references comprise the Bibliography, with the helpful innovation of a brief resume of the gist of each. Besides providing additional information this prevents "wild-goose-chases" after apparently promising titles.

Because the tubes are each treated in the same methodical manner, similarities and differences are easily grasped and can be quickly located when the book is used as a reference work. Storage tubes suitable for use with electronic computers are, of course, included, including the interesting case of the kinescope with the external electrode of metal foil.

Co-author Knoll is well known in the field and is responsible for four tubes that are treated impartially along with the rest.

The book is devoid of mathematical expressions, this aspect being treated in many of the cited references. Informative circuit diagrams and the essentials of construction of the tubes are given.

In view of the modest price, anyone who must have an understanding of these devices can hardly afford to be without the book. — *Harry R. Lubcke*, Consulting Engineer, 2443 Creston Way, Hollywood 28, Calif.

1952-53 Motion Picture and Television Almanac

Published (1952) by Quigley Publications, 1270 Sixth Ave., New York 20, N.Y., i-l + 1010 pp. (including advt.), thumb indexed, 6 × 9 in. Price $5.00.

This is another in the imposing procession of these annual reference volumes, this one giving an increased attention to the television field. Much of the preliminary work and planning for this volume was done by the late Maurice D. Kann who died on May 15, 1952.

With from three to eleven subsections where appropriate, the volume contains these sections:

Who's Who in Motion Pictures and Television
Corporations
Theatre Circuits
Drive-In Theatres
Television and Radio
Pictures
Services
Theatre Equipment Services and Materials
Organizations
The Government Case
Codes and Censorship
The World Market
The Industry in Great Britain
The Press
Non-Theatrical Motion Pictures

Although not a technical or engineering book, this is a valuable and obvious source for data on many business and facilities aspects of the Society's field as well as a help in another amusement activity — settling a discussion.—V.A.

High Speed Photography Issue

This is a special number of the Scientific Section of *The Photographic Journal* for Sept.-Oct. 1952. The release describing this issue advises:

"It is claimed that this publication brings this very important subject completely up to date and it is a source of reference which every firm, government department, laboratory, educational insti-

tution, and individual interested in this field should have.

"It is quite obvious that a number of scientific workers and institutions, not directly specializing in photography and the kindred sciences, do not yet realize the necessity of maintaining a complete set of "Section B" of *The Photographic Journal*. With the approach of the Society's Centenary — 1953 — [this point should be emphasized]. Since its foundation on 20 January 1853, this world-wide organization has fostered all applications of photography, kinematography, photoengraving, and radiography since their very inception as we know them today. We confidently expect wide recognition of the work performed by this Society during the past one hundred years."

Those who attended the International Symposium on High-Speed Photography at the SMPTE Convention in October will recognize at least two respected acquaintances among the contributors to *The Photographic Journal's* special issue:

R. H. J. Brown, "Flash Cinematography"

W. D. Chesterman and G. T. Peck, "A Synchronized Flash-Discharge System for High-Speed 35mm Cinematography"

J. S. Courtney-Pratt, "Image Converter Tubes and Their Application to High Speed Photography"

R. A. Chippendale, "Image Converter Techniques Applied to High Speed Photography"

K. D. Froome, "An Electronically Operated Kerr Cell Shutter"

J. M. Meek and R. C. Turnock, "Electro-Optical Shutters as Applied to the Study of Electrical Discharges"

This issue is noted on its cover as costing five shillings. Annual rates and other information should be requested from The Royal Photographic Society, 16 Princes Gate, London, S.W.7.

Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D.C., or from the New York Public Library, New York, N.Y., at prevailing rates.

American Cinematographer

vol. 33, Aug. 1952

Hollywood Launches 3-D Film Production (p. 336) *J. Biroc*

The Vistascope . . . New Tool for Motion Picture Production (p. 338) *L. L. Ryder*

"Anistration" . . . Streamlined Animation Technique (p. 340) *A. Rowan*

Background Projection Photography (p. 342) *C. L. Anderson*

High-Speed Cinematography (p. 343) *J. H. Waddell*

vol. 33, Sept. 1952

WarnerColor — Newest of Color Film Process (p. 384) *E. B. DuPar*

Miniatures in Motion Picture Production (p. 386) *A. Rowan*

Camera Fill Lights (p. 388) *F. Foster*

Lighting for High-Speed Motion Pictures (389) *J. H. Waddell*

Wheels that Still Turn Backward (p. 390) *R. H. Cricks*

Filming the TV Dramatic Featurette (p. 392) *H. A. Lightman*

Now . . . Magnetic Sound for All Cine Films (p. 394) *J. Forbes*

Bild und Ton

vol. 5, Sept. 1952

Die Projektierung eingebauter Lichtspieltheater in Moskau (p. 271)

Schäden am 35-mm-Kino-Film (p. 279) *H. Mager*

British Kinematography

vol. 21, July 1952

Magnetic Sound on 16mm Edge-Coated Film; A Short Review of a Current Trend (p. 15)

vol. 21, Sept. 1952

A Test to Measure the Flammability of Kinematograph Safety Film (p. 61) *R. W. Pickard*

Latensification (p. 67) *P. Raibaud*

Electrical Communication

vol. 29, Sept. 1952

Low-noise Traveling-Wave Tube (p. 234) *A. G. Peifer, P. Parzen and J. H. Bryant*

Electronics

vol. 25, Aug. 1952

Improving TV System Transient Response (p. 110–113) *John Ruston*

vol. 25, Oct. 1952

A Phase Indicator for Color Television (p. 112) *K. Schlesinger and L. W. Nero*

International Projectionist

vol. 27, July 1952

Heart of the Projector Mechanism (p. 5) *R. A. Mitchell*

Fox Unveils Eidophor, Arc-Lit Color TV (p. 14)

vol. 27, Aug. 1952

Heart of the Projector Mechanism, Pt. II (p. 8) *R. A. Mitchell*

vol. 27, Sept. 1952

Heart of the Projector Mechanism, Pt. III (p. 5) *R. A. Mitchell*

Stereosound Enhances Eidophor TV (p. 11)

Kino-Technik

no. 7, July 1952

Der neue Tonschmalfilmprojektor Elektor 16T3 (p. 171)

Infrarotfilm in der wissenschaftlicken Kinematographie (p. 172) *J. Rieck*

Jetzt auch Stereofilm im eigenen Heim (p. 177) *H. Lüscher*

no. 9, Sept. 1952

Berlins Anteil an der deutschen Filmindustrie (p. 208) *H. Müting*

Aus der Arbeit der Berliner kinotechnischen Betriebe (p. 209)

Akustik im Tonfilmtheater (p. 214) *W. Bausch*

"Filmosound 202" schafft neue Möglichkeiten für den 16-mm-Film (p. 216) *W. Beyer*

Tonaufnahmegeräte und Mischanlage der Western Electric (p. 218)

Störungen bei der Vorführung von Tonfilmen (p. 221) *K. Braune and H. Tummel*

Motion Picture Herald

vol. 188, Oct. 1952

(Better Theaters Section)

How the New Four-Inch Lenses Give a Brighter Picture (p. 10) *G. Gagliardi*

Getting into the Drive-in Business, Pt. 8, Planning the Main Building (p. 11) *W. P. Smith*

This is Cinerama on Broadway (p. 14)

Proceedings of the I.R.E.

vol. 40, Aug. 1952

Requisite Color Bandwidth for Simultaneous Color-Television Systems (p. 909–912) *Knox McIlwain*

Elimination of Moire Effects in Tri-Color Kinescopes (p. 916–923) *E. G. Ramberg*

Cathode-Ray Picture Tube With Low-Focusing Voltage (p. 937–945) *C. S. Szegho*

vol. 40, Oct. 1952

An Experimental System for Slightly Delayed Projection of Television Pictures (p. 1177) *P. Mandel*

Gamma Correction in Constant Luminance Color Television Systems (p. 1185) *S. Applebaum*

Radio and Television News

vol. 48, Aug. 1952

Cinemagnetic Recording (p. 46) *A. C. Blaney*

The TV Picture Tube (p. 50) *W. Buchsbaum*

Tele-Tech

vol. 11, Oct. 1952

Television Control Room Layout (p. 48) *R. D. Chipp*

SMPTE Lapel Pins

The Society will have available for mailing after September 15, 1952, its gold and blue enamel lapel pin, with a screw back. The pin is a ½-in. reproduction of the Society symbol — the film, sprocket and television tube — which appears on the *Journal* cover.

The price of the pin is $4.00, including Federal Tax; in New York City, add 3% sales tax.

Obituary

Percy D. Brewster died on October 27 at his home at East Orange, N.J., after a long illness. He had retired 12 years ago. His work as a motion picture engineer led him to credit as the inventor of several color photographic processes, with 360 patents granted to him. He was President of the Brewster Color Film Corp. of Newark, N.J., and of the former Revelation Film Corp. of London.

He became a member of the Society of Motion Picture Engineers in 1929 and was made a Fellow in 1934. He was cited by the Royal Society of London for his work in color photography and was the first to make a color photograph of President Wilson. He was graduated from Cornell University in 1906.

New Members

The following members have been added to the Society's rolls since those last published. The designations of grades are the same as those used in the 1952 Membership Directory.

Honorary (H) Fellow (F) Active (M) Associate (A) Student (S)

Adair, George P., Consulting Engineer, George P. Adair Engineering Co., 1610 Eye St., N.W., Washington 6, D.C. (M)

Adler, Benjamin, Engineer, Adler Communications Laboratories, 1 LeFevre La., New Rochelle, N.Y. (M)

Bras, Rene, President, Science Pictures, Inc., 5 E. 57 St., New York, N.Y. (M)

Diner, Leo, Motion Picture Producer, 332 Golden Gate Ave., San Francisco, Calif. (M)

Ewing, Jasper G., Jr., Partner, Jasper Ewing & Sons. **Mail:** 725 Poydras St., New Orleans, La. (A)

Friedman, Jacob, Photographer, Emerson Electric Manufacturing Co. **Mail:** 7010 Tulane, University City 5, Mo. (A)

Gallagher, James C., President, Gallagher Films, Inc. **Mail:** 137 N. Oakland Ave., Green Bay, Wis. (A)

Gilreath, Walter W., District Manager, RCA Service Co., Inc. **Mail:** 3732 Stanford St., Dallas 5, Tex. (M)

Goldman, Leslie A., Production Manager (Motion Pictures), Tempo Productions, Inc., 588 Fifth Ave., New York 36, N.Y. (A)

Hildebrandt, Carl E., Optical Field Technician, Sandia Corp. **Mail:** 674 Sunset Dr., P.O. Box 410, Brawley, Calif. (A)

Hill, Armin J., Research Physicist, Motion Picture Research Council, 1421 North Western Ave., Los Angeles 27, Calif. (M)

Inglis, Andrew F., Radio Engineer, McIntosh & Inglis. **Mail:** 4619 Norwood Dr., Chevy Chase, Md. (M)

Johnson, Howard R. H., Assistant to Deputy Chief, Operations, Air Photographic & Charting Service, 3701 North Broad St., Philadelphia, Pa. (A)

Johnston, Capt. Clint, Chief, Motion Picture & Video Production Division, Air Photographic & Charting Service, U.S. Air Force, 3701 N. Broad St., Philadelphia 40, Pa. (A)

Kaplan, Fred M., Geo. W. Colburn Laboratory, Inc. **Mail:** 6508 Rockwell, Chicago 45, Ill. (A)

Lee, Harold V., President and Manager, Color-vision, Inc., 129 W. Alameda Ave., Burbank, Calif. (M)

Lewis, Jack, Owner, Jack Lewis Studios, 705 East Main St., Richmond 19, Va. (M)

Lohnes, Kenneth F., Cine Technician, Warner Brothers Studio. **Mail:** 4604 Cahuenga Blvd., North Hollywood, Calif. (A)

Mack, Donald, TV Sales Manager, Production Assistant, Filmack Corp. **Mail:** 8626 Prairie Rd., Skokie, Ill. (M)

Oldershaw, Malcolm J., Consulting Engineer, Canadian Marconi Co., Ltd., 2442 Trenton Ave., Mount Royal, Quebec, Canada. (A)

Ottemiller, William H., Jr., Division Manager, Quality Control, Television Picture Tube Division, Sylvania Electric Products, Inc. **Mail:** R.D. #1, Seneca Falls, N.Y. (M)

Pike, Howland, District Manager, Ansco Division, General Aniline & Film Corp. **Mail:** 7125 Maple Ave., Takoma Park 12, Md. (M)

Powis, Chauncey G., TV Engineer, KDYL-TV. **Mail:** 59½ Hillside Ave., Salt Lake City, Utah. (A)

Rowley, Basil G. H., Technical Representative, Marconi's Wireless Telegraph Co., Ltd., 23–25 Beaver St., New York 4, N.Y. (A)

Sandwick, Luther M., Vice-President, Wilcox-Gay Corp., Charlotte, Mich. (M)

Sproul, Thomas G., Film Technician, Consolidated Film Industries. **Mail:** 4461 Morse Ave., North Hollywood, Calif. (A)

CHANGES IN GRADE

Bury, John L., Jr., (S) to (A)

Gausman, Harvey E., (A) to (M)

MacDonald, Joseph W., (S) to (A)

Wicker, L. P., (A) to (M)

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April *Journal*.

Chemical Corner

Edited by Irving M. Ewig for the Society's Laboratory Practice Committee. Suggestions should be sent to Society headquarters marked for the attention of Mr. Ewig. Neither the Society nor the Editor assumes any responsibility for the validity of the statements contained in this column. They are intended as suggestions for further investigation by interested persons.

Foam Prevention Tributyl phosphate has good antifoaming properties and in addition is colorless and odorless. This product is marketed by Apex Division of Food Machinery and Chemical Corp., Niro, W. Va.

Substitute for Metol *British Kinematography* has an article in the February 1952 issue (vol. 20, no. 2) describing a substitute for metol. It is 1-phenyl 3-pyrazolidene. It is white and odorless; and persons sensitive to metol poisoning are reported unaffected by this so-called Phenidone. Like metol it is sensitive to pH and is soft working when used alone. In combination with hydroquinone it gives a more rapid, less grainy image and produces less fog. It also yields a high contrast with hydroquinone and has a lower exhaustion rate. It is possible to match a metol-hydroquinone developer with a phenidone-hydroquinone developer.

Construction of Water Purifier An interesting article, "Pure water for your darkroom," in *American Photography*, (vol. 45, 341–346, June 1951), by H. F. Walton, describes a method for constructing a water-purification, ion-exchange unit. All that is required is some laboratory glassware and commercial resins.

Try It Before You Buy It A method for rapid identification of nickel alloys, stainless steels, etc., might be of value in the motion picture laboratory where the question of materials of construction of processing equipment often comes up. Such a quick test procedure has been described in a pamphlet by Henry B. Lee of Eastman Kodak and published as Special Technical Bulletin #98 by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. The metals or groups of metals for which methods of testing are described are nickel, monel metal, inconel, stainless steel #316, other chrome nickel, nickel stainless steels, straight chromium stainless steels as a class, etc. All the requirements for testing are seven common chemicals, a stirring rod, a medicine dropper, a porcelain spot plate and an abrasive cloth.

Tank Cleaning Advice L. B. Russell Chemicals, Inc., of 60 Orange St., Bloomfield, N.J., markets a chemical preparation called "Wizz" which is used for cleaning developing tanks. Reported safe to handle, noncorrosive and useful with any type of material, it is dissolved in water. The solution is kept overnight in the developer tank which is then washed out thoroughly to leave the tank free of chemical deposit and crustation. Periodic treatment of developer tanks will add to uniformity of the developer and lengthen its life, eliminate dirt problems and generally improve processing.

Film Processing Chemistry A series of articles by various authorities dealing with some fundamental chemistry of film processing appeared in *British Kinematography*, vol. 20, no. 2, Feb. 1952. One of these articles discusses the various chemical constituents of a developer and their roles; the chemical reactions of a developer and the products formed. The matter of the dependence of the rate of replenishment on the amount of bromide that can be tolerated in the developer is discussed. It is also pointed out that the work of development is performed by metol while hydroquinone serves to reverse the oxidized metol back to its original functional state and thereby becomes oxidized itself. Therefore, the maintenance of the metol concentration in the developer is easy compared to that of hydroquinone. Some suggestions about electrolytic recovery of silver and the regeneration of hypo are also discussed.

Testing the Exhaustion of a Fixing Bath L. G. Sandys presents his views about how to increase the efficiency of fixing baths and methods of testing in an article, "Efficiency and conservation of fixing baths," published in *The British Journal of Photography*, Vol. 98, pp. 662–3, Dec. 1951. If a yellow precipitate persists upon the addition of a 4% potassium iodide solution to ten parts of the fixer, it is exhausted. This can be confirmed by agitation with a paddle of some kind and if a lasting froth develops it indicates that the bath is spent.

Temperature Control for Film Processing Solutions U.S. Patent #2,584,294 assigned to Remington Rand describes a procedure for isolating the developer and fixer sections of a processing machine by a compartment and circulating heated air from the drying compartment through this chamber.

Filter-Aid Aid During the present strike at Johns Manville, users of their Celite filter aids find themselves in a difficult situation. Perhaps the Brown Company of Berlin, N.H., have a solution to this problem with their "Solka-floc" which they claim (1) prevents "leak through" in the filtration process, (2) enables high flow rates, (3) enables controlled porosity in the filter cake and (4) reduces labor cost by diminishing the number of times filter presses have to be cleaned. The general sales office is at 150 Causeway St., Boston, Mass.

New Method of Rust Prevention VPI (Vapor Phase Inhibitor) is chemically known as dicyclohexyl ammonium nitrate and is manufactured commercially by Monsanto Chemical Company. By vaporizing and allowing it to deposit on the product, it is reported to prevent corrosion. It may be used by impregnating paper and lining a drawer with this paper. This will prevent corrosion of anything kept in this drawer. However, its methods of application are numerous. It is nonflammable and will reach areas where usual corrosion preventatives cannot be applied. One gram of VPI provides protection for one cubic foot of metal if properly wrapped to prevent loss of vapor.

Meetings

American Society of Photogrammetry, Annual Meeting, Jan. 14–16, Shoreham Hotel, Washington, D. C.

American Institute of Electrical Engineers (Symposium on the Science of Music and Its Reproduction — 3d Lecture), Jan. 15, Engineering Societies Bldg., New York, N. Y.

Society of Motion Picture and Television Engineers, Southwest Subsection Meeting, Jan. 16, Dallas, Tex.

American Institute of Electrical Engineers, Winter General Meeting, Jan. 19–23, New York, N. Y.

American Physical Society, Annual Meeting, Jan. 22–24, Cambridge, Mass.

Institute of Radio Engineers Conference and Electronics Show, 5th Annual Southwestern Conference and Show, Feb. 5–7, San Antonio, Tex.

American Institute of Electrical Engineers (Symposium on the Science of Music and Its Reproduction — 4th Lecture), Feb. 20, Engineering Societies Bldg., New York, N. Y.

National Electrical Manufacturers Association, Mar. 9–12, Edgewater Beach Hotel, Chicago, Ill.

Society of Motion Picture and Television Engineers, Southwest Subsection Meeting Mar. 16, Fort Worth, Tex.

Inter-Society Color Council, Annual Meeting, Mar. 18, Hotel Statler, New York, N. Y.

Optical Society of America, Mar. 19–21, Hotel Statler, New York, N.Y.

American Physical Society, Joint Meeting with APS Southeastern Section, Mar. 26–28, Duke University, Durham, N.C.

American Physical Society, Apr. 30–May 2, Washington, D.C.

Acoustical Society of America, May 7–9, Hotel Warwick, Philadelphia, Pa.

Society of Motion Picture and Television Engineers, Southwest Subsection Meeting, May 20, Dallas, Tex.

American Physical Society, June 18–20, Rochester, N.Y.

American Institute of Electrical Engineers, Summer General Meeting, June 29–July 3, Atlantic City, N.J.

Biological Photographic Association, 23d Annual Meeting, Aug. 31–Sept. 3, Hotel Statler, Los Angeles, Calif.

The Royal Photographic Society's Centenary, International Conference on the Science and Applications of Photography, Sept. 19–25, London, England

Theatre Equipment and Supply Manufacturers' Association Convention (in conjunction with Theatre Equipment Dealers' Association and Theatre Owners of America), Oct. 31–Nov. 4, Conrad Hilton Hotel, Chicago, Ill.

Theatre Owners of America, Annual Convention and Trade Show, Nov. 1–5, Chicago, Ill.

National Electrical Manufacturers Association, Nov. 9–12, Haddon Hall Hotel, Atlantic City, N.J.

Employment Service

Positions Wanted

Audio-Visual School of Education Graduate: M.A., Audio-Visual Education, New York University. Sound background in personnel and contact work, attractive, single, personable. Prefer position New York or New Jersey area. Spent 3 years abroad, civilian, Special Services Director. Miss Fredericka Appleby, 810 Broadway, Newark, N.J. HUmboldt 5-4582.

TV Producer-Director: Formerly Chief of Production in Army's first mobile TV system, experience in writing-directing high-speed, low-cost instructional productions; TV producer-director, KRON-TV San Francisco, five shows weekly. Desire connection in educational TV, preferably employing kinescope technique; married; prefer West Coast, but willing to travel; résumé, script samples, pictures of work — on request. Robert Lownsbery, 1116 E. Claremont St., Pasadena 6, Calif.

Research, field engineering, manufacturing opportunity for B.S. Electrical Engineering candidate, Jan. 1953; Scholarship student, M.I.T.; studied in Germany, 1945–1950. Languages: German, Polish, Russian and English. Some radio shop experience; also M.I.T. Library and Engineering Dept. Single, no dependents; Military Status, 5A (over 26). Prefer location in East. Joseph Liebermann, 513 Beacon St., Boston, Mass.

Position Available

Wanted: Young engineer, mechanical or electrical deg; with liking for fine machinery and creating it, some experience in mechanical design and some knowledge of optics or electronics; for work on development of new products; applications held in full confidence. Send complete résume to Sherman Fairchild and Assoc., Rm 4628, 30 Rockefeller Plaza, New York, Attn. Mr. Fairbanks.

Appearance Technology may not be a new term but it is being pushed into the light by Richard S. Hunter who announces that he has formed Hunter Associates Laboratory, 5421 Brier Ridge Rd., Falls Church, Va., a consulting group devoted exclusively to appearance and related optical properties of materials — color, diffuse reflectance, gloss or luster, turbidity, haze, opacity and the like. Mr. Hunter, who has left the position of Chief Optical Engineer with the Henry A. Gardner Laboratory at Bethesda, Md., reports that his organization is equipped to test materials for either routine or special appearance properties and to design appearance-testing instruments.

Papers Presented
at the Washington Convention, October 6–10

By Sessions

MONDAY AFTERNOON — Television Session

J. E. Hayes, Canadian Broadcasting Corp., Montreal, Canada, "Television Facilities of the Canadian Broadcasting Corporation."

R. D. Chipp, Du Mont Television Network, New York, "Film Projection Using Image Orthicon Cameras."

L. L. Pourciau, General Precision Laboratory, Inc., Pleasantville, N.Y., "Television Camera Equipment of Advanced Design."

W. E. Stewart, Radio Corporation of America, Engineering Products Division, Camden, N.J., "New Professional Television Projector."

MONDAY EVENING — Television Session

William H. Offenhauser, Jr., New Canaan, Conn., "Nomenclature for Motion Pictures and Television in the Society of Motion Picture and Television Engineers."

Pierre Mertz, Bell Telephone Laboratories, New York, "Influence of Echoes on Television Transmission."

A. V. Loughren, Hazeltine Corp., Little Neck, L.I., N.Y., "The Accomplishments and Recommendations of the National Television System Committee in the Field of Color Television."

TUESDAY MORNING — Television Session

Mary Ellen Widdop, RCA Victor Division, Camden, N.J., "A Review of Work on Dichroic Mirrors and Their Light-Dividing Characteristics."

Ralph E. Lovell, National Broadcasting Co., Hollywood, Calif., "Time-Zone Delay of Television Programs by Means of Kinescope Recording."

Ralph E. Lovell and Robert M. Fraser, National Broadcasting Co., Hollywood and New York, "Instrumentation and Sensitometry Employed in Kinescope Recording."

John S. Auld, Signal Corps Photo Center, Long Island City, N.Y., "Facilities and Employment of the Signal Corps Mobile Television System."

TUESDAY AFTERNOON — Television Session

Karl Freund, Photo Research Corp., Burbank, Calif., "Shooting Live Television Shows on Film."

Ferenz Fodor, Filmcraft Productions, Hollywood, Calif., "Filmcraft's Camera Control System."

TUESDAY EVENING — General Session

Leonard A. Herzig, Prestoseal Manufacturing Corp., Long Island City, N.Y., "Method and Apparatus for Splicing Motion Picture Safety Film Without the Use of Cements or Adhesives."

Gustav Jirouch, Cine-Television Equipment, Ltd., Kent, England, "The Robot Automatic Film Splicer."

R. Kingslake (Committee Chairman), Eastman Kodak Co., Rochester, N.Y., "Optics Committee Report."

E. H. Bowlds, E. H. Bowlds Engineering Co., Los Angeles, Calif., "An Animation Stand of New Design."

John A. Rodgers, Eastman Kodak Co., Rochester, N.Y., "Projector for 16mm Optical and Magnetic Sound."

Ann Hyer, Division of Audio-Visual Education, National Education Association, Washington, D.C., "Planning Classrooms for Use of Audio-Visual Materials."

WEDNESDAY MORNING (Concurrent Sessions)
——— Film Processing Session

Leonhard Katz and William F. Esthimer, Raytheon Manufacturing Co., Newton, Mass., "Further Experiments in High-Speed Processing Using Turbulent Fluids."

F. Dana Miller, Eastman Kodak Co., Rochester, N.Y., "Rapid Drying of Normally Processed Black-and-White Motion Picture Films."

Edward B. Krause and Joseph A. Tanney, S.O.S. Cinema Supply Corp., New York, "The Bridgamatic Developing Machine."

E. K. Carver (Committee Chairman), Eastman Kodak Co., Rochester, N.Y., "Film Dimensions Committee Report."

John Streiffert, Kodak Research Laboratories, Rochester, N.Y., "A Fast-Acting Exposure Control System for Color Motion Picture Printing."

A. A. Duryea, T. J. Gaski and L. Mansfield, Pathe Laboratories, Inc., New York, "Film Presentation of Various Productions on Eastman Negative-Positive Color Process."

——— High-Speed Photography Session

John H. Waddell, Wollensak Optical Co., Rochester, N.Y., "Introduction of the Symposium and History of High-Speed Photography."

Richard O. Painter (Vice-Chairman), General Motors Proving Ground, Milford, Mich., "High-Speed Photography Committee Report."

Norman F. Barnes, General Electric Co., Schenectady, N.Y., "Optical Techniques for Fluid Flow."

Major P. Naslin, French Laboratory of Armament, Paris, France, "Some Simple Electronic High-Speed Photographic and Cinematographic Devices."

R. M. Blunt, Institute of Industrial Research, University of Denver, Denver, Colo., "The Use of Photography in the Underground Explosion Test Program, 1951–1952."

WEDNESDAY NOON — High-Speed Photography Luncheon

A. C. Keller, Bell Telephone Laboratories, New York, Keynote Address, "The Economics of High-Speed Photography."

WEDNESDAY AFTERNOON — High-Speed Photography Session

Louis F. Ehrke, Westinghouse Electric Corp., Bloomfield, N.J., "History of Ultra High, Speed X-Ray Exposures and X-Ray Motion Pictures."

S. J. Jacobs, Naval Ordnance Laboratory, White Oak, Md., "Space-Time Resolution as a Criterion for Comparing Ultra-High-Speed Photographs."

Roger Wilkinson, Bell Telephone Laboratories, New York, and Harry Romig, Hughes Aircraft Co., Culver City, Calif., "Space-Time Relationships With Multiple Camera Installations."

H. Schardin, Laboratoire de Recherches, Weil Am Rhein, Baden, Germany, "The Development of High-Speed Photographic Techniques in Europe."

Morton Sultanoff, Terminal Ballistics Laboratory, Aberdeen Proving Ground, Md. "Photographic Instrumentation in the Study of Explosive Reactions."

THURSDAY MORNING — High-Speed Photography Session

Harold E. Bauer and Webster Blake, Douglas Aircraft Co., Santa Monica, Calif., "The Applications of Wide-Angle Optics to Moderately High-Speed Motion Picture Cameras."

J. S. Courtney-Pratt, University of Cambridge, Cambridge, England, "Two New Methods of High-Speed Photography."

H. W. Greenwood, Canadian Armament Research and Development Establishment, Ottawa, Canada, "Information Discussion of Image-Convertors and Other Ballistic Methods."

F. W. Bowditch, General Motors Corp., Detroit, "The Use of Motion Picture Photography for Combustion Research."

Amy E. Griffin and Elmer E. Green, U.S. Naval Ordnance Test Station, China Lake Calif., "Accuracy Limitations on the Use of High-Speed Metric Photography."

W. O. Johnson, E. I. du Pont de Nemours & Co., Wilmington, Del., "High-Speed Photography in the Chemical Industry."

THURSDAY AFTERNOON (Concurrent Sessions)
——— General Session

R. D. Bennett, Technical Director of the Naval Ordnance Laboratory, White Oak, Md., "The Naval Ordnance Laboratory."

J. S. Watson, Jr., and S. A. Weinberg, University of Rochester School of Medicine and Dentistry, Rochester, N.Y., "70mm Motion Picture Camera for X-Ray Motion Pictures."

W. W. Lozier (Committee Chairman), National Carbon Co., Fostoria, Ohio, "Screen Brightness Committee Report."

Armin J. Hill, Motion Picture Research Council, Hollywood, Calif., "A Simple Formula for Taking Stereoscopic Motion Pictures."

Armin J. Hill, Motion Picture Research Council, Hollywood, Calif., "A First-Order Approximation for the Mathematical Treatment of Diffusing Surfaces."

Allen Stimson and Edward H. Fee, General Electric Co., West Lynn, Mass., "Color and Reflectance of Human Flesh."

——— High-Speed Photography Session

Harold C. Barr, Sandia Corp., Albuquerque, N.M., "High-Speed Photographic Instrumentation in Field Tests."

Berlyn Brixner, Los Alamos Scientific Laboratory, Los Alamos, N.M., "High-Speed, Rotating-Mirror Frame Camera."

A. M. Erickson, Naval Ordnance Laboratory, White Oak, Md., "Photographic Instrumentation of Timing Systems."

H. Schardin, Weil Am Rhein, Baden, Germany, "High-Speed Spark Photography."

I. L. Stern and J. H. Foster, Material Laboratory, New York Naval Shipyard, Brooklyn, N.Y., "High-Speed Photographic Techniques for the Study of the Welding Arc."

Charles T. Lakin, U.S. Naval Ordnance Test Station, Inyokern, Calif., "The 70-mm Test Vehicle Recorder."

W. R. Stamp and R. P. Coghlan, Royal Naval Scientific Service, United Kingdom, "Growth and Decay of Light Measured Photographically From Flash Discharge Tubes."

W. D. Chesterman, Royal Naval Scientific Service, United Kingdom, "New Precision Rotating Prism High-Speed Motion Picture Camera."

W. D. Chesterman, Royal Naval Scientific Service, United Kingdom, "Further Developments in High-Speed Photography in England."

Carl G. Jennergren, Research Institute of National Defense, Stockholm, Sweden, "High-Speed Photography in Sweden."

THURSDAY EVENING (Current Sessions)

——— Symposium on 16mm Equipment Maintenance

Bernard A. Cousino, Cousino, Inc., Toledo, Ohio, "Equipment Maintenance — Key to Success."

Henry H. Wilson, Ampro Corp., Chicago, "Operation of a Manufacturer's Service Organization."

Fred Whitney, SMPTE, New York, and R. A. House, Film Recording Group, RCA Victor Division, Camden, N.J., "Test Films for 16mm Equipment Maintenance."

Thomas C. Sheehan, Visual Instruction Office, Washington Public Schools, Washington, D.C., "Maintaining Visual Education Equipment in a Large City School System."

O. T. Bright, Bell & Howell Co., Chicago, "Selection, Training and Equipping Field Service Stations for Repair of 16mm Projection Equipment."

Philip M. Cowett, Bureau of Ships, U.S. Navy Dept., Washington, D.C., "Navy Maintenance of 16mm Projection Equipment."

——— High-Speed Photography Session

Karl W. Maier, Springfield Armory, Springfield, Mass., "A Procedure for Complete Analysis of High-Speed Motion Picture Data."

C. David Miller and Arthur Scharf, Battelle Memorial Institute, Columbus, Ohio, "An Isotransport Camera for 100,000 Frames per Second."

Robert D. Shoberg, Army Ordnance Corp., White Sands Proving Ground, Las Cruces, N.M., "High-Speed Instrumentation of Guided Missiles."

Kenneth Shaftan, J. A. Maurer, Inc., Long Island City, N.Y., "Progress in Photographic Instrumentation in 1951."

FRIDAY MORNING (Concurrent Sessions)

——— Sound Recording and Reproduction

W. K. Grimwood and J. R. Horak, Kodak Research Laboratories, Rochester, N.Y., "Optimum Slit Height in Photographic Sound-Track Reproducers."

J. K. Hilliard (Committee Chairman), Altec Lansing Corp., Beverly Hills, Calif., "Sound Committee Report."

Robert Dressler and Albert Chesnes, Paramount Pictures Corp., New York, "Sound-on-Film Recording Using Electro-Optic Crystal Techniques."

John G. Frayne, Westrex Corp., Hollywood, Calif., and J. P. Livadary, Columbia Pictures Corp., Hollywood, Calif., "Dual Photomagnetic Intermediate Studio Recording."

Maxwell A. Kerr, Navy Dept., Bureau of Ships, Washington, D.C., "16mm Release-Print Inspection — Some Observations and Proposals."

——— High-Speed Photography Session

Joshua Fields, Louis Fields, Eleanor Gerlach and Myron Prinzmetal, Institute for Medical Research, Cedars of Lebanon Hospital, Los Angeles, "High-Speed Cine-Electrocardiography."

Willard E. Buck, Los Alamos Scientific Laboratory, Los Alamos, N.M., "Transient Pressure Recording With a High-Speed Interferometer Camera."

Floyd Stratton and Kurt Stehling, Bell Aircraft Co., Buffalo, N.Y., "Applications of High-Speed Photography in Rocket Motor Research."

Harry R. Clason, National Advisory Committee for Aeronautics, Langley Field, Va., "A Method of Lighting Large Fields for High-Speed Motion Picture Photography."

William P. Holloway, U.S. Naval Ordnance Test Station, Inyokern, Calif., "A Theodolite Method of Camera Calibration."

Earl Quinn, Eastman Kodak Co., Rochester, N.Y., "A Case History of a High-Speed Tapping Operation."

FRIDAY AFTERNOON (Concurrent Sessions)

——— Symposium on Magnetic Striping of Film

Edward Schmidt, Reeves Soundcraft Corp., Springdale, Conn., "Commercial Experiences With Magnastripe Production."

B. L. Kaspin, A. Roberts, H. Robbins and R. L. Powers, Bell & Howell Co., Chicago, "Magnetic Striping Techniques and Characteristics."

A. H. Persoon, Minnesota Mining and Manufacturing Co., St. Paul, Minn., "Magnetic Striping of Photographic Film by the Laminating Process."

Thomas R. Dedell, Eastman Kodak Co., Rochester, N.Y., "Magnetic Sound Tracks for Processed 16mm Motion Picture Film."

G. A. Del Valle and L. W. Ferber, RCA Victor Division, Camden, N.J., "Notes on Wear of Magnetic Heads."

Ernest W. Franck, Reeves Soundcraft Corp., Springdale, Conn., "A Study of Drop-Outs in Magnetic Film."

E. W. D'Arcy, De Vry Corp., Chicago, "Standardization Needs for 16mm Magnetic Sound."

——— High-Speed Photography Session

David C. Gilkeson and A. E. Turula, Wollensak Optical Co., Rochester, N.Y., "Optical Aids for High-Speed Photography."

Frederick P. Warrick, Frederick P. Warrick Co., Bloomfield Hills, Mich., "A High-Speed Recording Camera Featuring Constant Film Velocity and Large Film Capacity."

John H. Waddell, Wollensak Optical Co., Rochester, N.Y., "Full-Frame 35mm Fastax Camera."

M. Roganti, Wright-Patterson Air Force Base, Dayton, Ohio, "New Air Force Recording Camera."

Myron A. Bondelid, U.S. Naval Ordnance Test Station, Inyokern, Calif., "The M-45 Tracking Camera."

Charles A. Hulcher, Charles A. Hulcher Co., Hampton, Va., "70mm High-Speed Sequence Camera."

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THROUGH the cooperation of the Library Binding Institute, an organization of binderies which specializes in binding publications into volumes, arrangements have been made to give information and assistance to Society members who want to have their *Journals* bound. This work may be done in accordance with standards of materials and construction required for durability, service and accessibility by college, reference and public libraries. The American Library Association and the Library Binding Institute have cooperated in promulgating "Minimum Specifications for Class A Library Binding" based on research and production and performance experience.

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